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MASTER OF SCIENCE

IN

MEDICAL IMAGING TECHNOLOGY

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BY

POOJA SAINI

ENROLMENT NO-950122469

MEDICAL IMAGING TECHNOLOGY

EVALUATION OF THE BRAIN STEM ON THE BASIS OF AGE, GENDER, BMI BY USING 1.5 TESLA MRI

SANTOSH MEDICAL COLLEGE & DEEMED TO BE UNIVERSITY
GHAZIABAD No.1, Sector 12, Santosh Nagar, PratapVihar, Ghaziabad, Uttar Pradesh, 201009

DISSERETION
ON

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THE SUBMITTED IN PARTIAL FULFILMENT OF THE

REQUIREMENTS FOR THE AWARD OF A

MASTER OF SCIENCE DEGREE

IN

MEDICAL IMAGING TECHNOLOGY

BY

POOJA SAINI

ENROLLMENT NO- 950122469

UNDER THE SUPERVISION

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Sr No	FULLFORM	ABERRATION
1	MAGNETIC RESONANCE IMAGING	MRI
2	TIME TO ECHO	TE
3	REPETITION TIME	TR
4	RADIO FREQUANCY	RF
5	ANTEROPOSTERIOR	AP
6	FILD OF VIEW	FOV
7	CENTIMETER	Cm
8	MID BRAIN ANTEROPOSTERIOR	MBAP
9	PONS ANTEROPOSTERIOR	PAP
10	MEDULLAPONTOMEDULLARY JUNCTION	MPMJ
11	MEDULLACERVICOMEDULLARY JUNCTION	MCMJ

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CHAPTER-1

INTRODUCTION

1.1 BRAIN ANATOMY

The cranial cavity houses the brain, which is surrounded by the meninges, which are the Dura mater, arachnoid mater, and pia mater are essential components in the body. just like spinal cord. At the foramen magnum, the meninges and their spinal counterparts are continuous. The diencephalon, pons, midbrain, cerebellum, medulla oblangata and cerebrum comprise the brain. The brainsetm composed of medulla, pons, and midbrain(1)

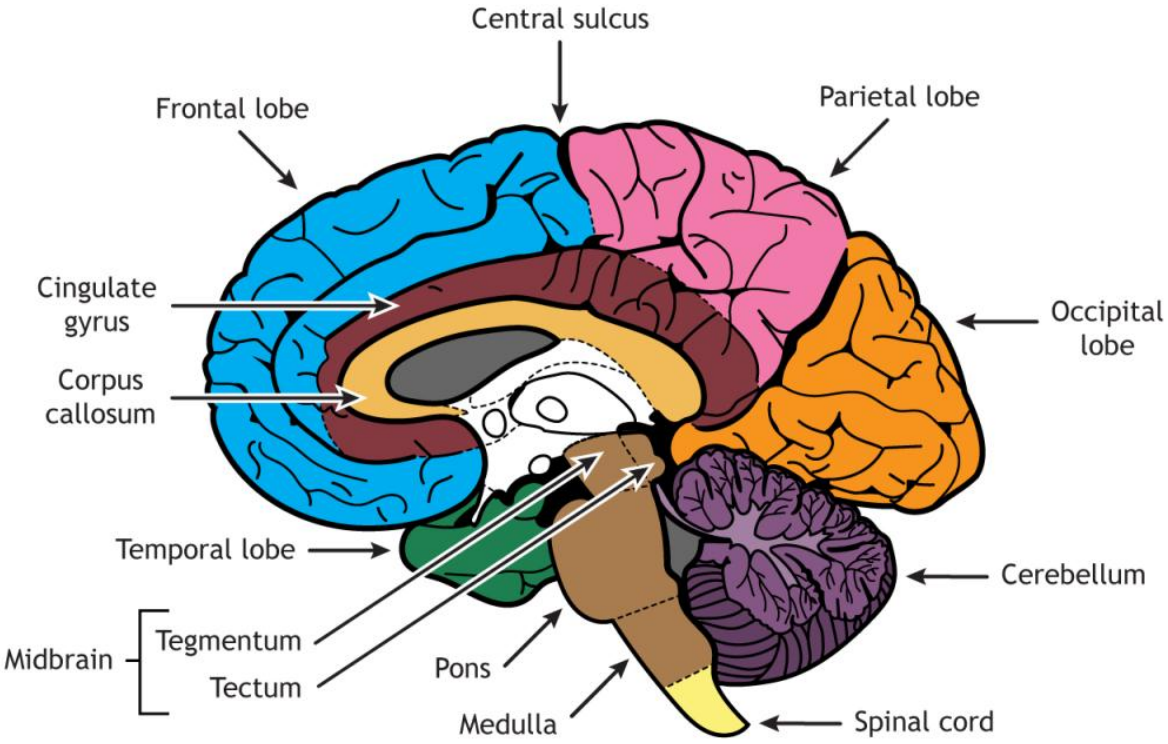


FIG 1.1:- Human brain structure.

1.2 NERVOUS SYSTEM

The body's primary governing and coordinating system is the nervous system. It is in charge of memory, intelligence, and judgment. The highly evolved nervous system comes as a cost

of regrowth, it is the body's most intricate system. It adapts the body to its environment and controls all physiological processes, whether conscious and unconscious. The information is gathered via the nervous system's sensory component from the environment and facilitates learning and expertise, while the motor component is in charge of for the body's reactions. The typical adult brain has a weight of between 1500 and 2000 grams when in air. The brain is only 50 grams in weight, which is comfortable because it floats in cerebrospinal fluid. An adult has between 180 and 200 billion neurons brain.

The nervous system is composed of two main parts.-

The central nervous system and the peripheral nervous system are two distinct systems that play a crucial role in our overall health and well-being .

1.3 GREY AND THE WHITE MATTER

Neurons are units of nervous tissue, consisting of cell bodies, dendrites, and axons supported by neuroglia and blood vessels. Grey matter, containing cell bodies, neuroglial cells, and blood vessels, covers the cortex and is found deep to the cortex and superficial to ganglia/nuclei.

1.4 CENTRAL NERVOUS SYSTEM

The spinal cord, extending from the skull to the lumbar vertebra, controls motor neurons, receives sensory input, and controls visceral functions. It contains an ascending and decreasing route for transmitting information to the brain, and sends motor commands to motor neurons. (2)

1.5 MENINGE

1.5.1DURA MATTER

It consists of two layers that enclose the cerebral venous sinuses: the inner meningeal layer and the outer endosteal layer. Four folds formed by the meningeal layer split the cranial cavity into interconnected chambers housing distinct brain regions.

1.5.2. ARACHNOID MATTER

The brain is surrounded loosely by a thin, translucent membrane called the arachnoid (Latin for "cobweb-like") mater, which doesn't dip into many of the brain's sulci. Cerebrospinal fluid (CSF) and blood arteries are found in the subarachnoid space, which divides it from the pia and the dura.

1.5.3. PIA MATTER

A thin vascular membrane known as the pia mater, or loving mother in Latin, is found tightly within the brain, dipping into different sulci and other irregularities on its surface. It is made up of pia-glia and epi-pia. In reference to the bigger fissures of the cerebellum, the pia mater dips and produces folds. Blood veins pierce it to supply nutrients to the spinal cord and brain. (2)

1.6 CEREBROSPINAL FLUID CSF

Cerebrospinal fluid (CSF) is the fluid that passes through the ventricles of the brain ,the spinal cord's central canal and the subarachnoid space. It is translucent, colorless, and clear. A component of extracellular fluid.(3) There are roughly 150 milliliters of CSF in total. Approximately 200 ml per hour or 5000 ml per day are generated at this rate, CSF typically has a pressure of 60 to 100 mm H2O.(2) The choroid plexuses, tend to be located inside the ventricles, create the CSF. Inside the ventricles, choroid plexuses are tufts of capillary projections coated in ependymal and pia mater coverings. The lateral ventricles are where most of the CSF is produced.(3) Through the interventricular foramen of Morrow, CSF travels from each lateral ventricle to the 3rd ventricle. It travels via the cerebral aqueduct from the third ventricle to the fourth ventricle. Through the median and lateral ventricle openings, the CSF exits the 4th ventricle and travels to the subarachnoid areas of the cerebrum and the vertebral canal. A portion within the CSF then travels down the spinal cord's central canal. (2)In addition to maintaining a constant pressure surrounding these fragile structures, it supports and shields the brain and spinal cord function as a shock absorber and cushion between brain and the skull bones. It maintains the moisture content of the brain and spinal coard which allows for the possible exchange of waste products and nutrients between CSF and nerve cells.(4)

1.7 PARTS OF BRAIN

1.7.1 CEREBRUM

The main part of the brain called the cerebrum, or Latin brain, Pallium is another name for it. The location of this is in the anterior and middle cranial fossae., as well The supratentorial area of the posterior cranial fossa is a crucial area for brain function and developmen. It is made of some neuronal masses within the white matter known as basal ganglia nuclei, as well as outer grey matter and inner white matter. Each hemisphere has a chamber called as the lateral ventricle and a central structure known as the diencephalon.(2)

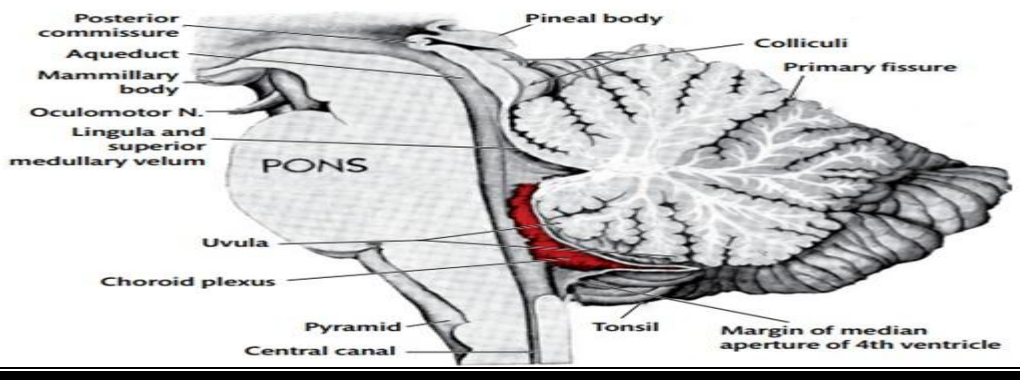
There are three surfaces on each hemisphere: the inferior surface, partially in contact with the falx cerebri, the medial surface, and the convex superolateral surface. The surface located above is convex. It ends at the occipital pole in the back and the frontal pole at the front. The most temporal lobe's anterior region is called the temporal pole. The brain's medial surface is not visible from the outside. Tentorial and orbital portions make up the inferior surface. The orbital portion is situated in the nasal cavity, the orbital roof, and the anterior cranial fossa.

The sphenoid's smaller wing is inserted into the stem of the lateral sulcus, separating it from the inferior tentorial section of the surface.

The tentorial portion terminates at the occipital pole after resting posteriorly on the tentorium cerebelli. Between the transverse and superior sagittal sinus grooves on the occipital bone, there is a fossa where the occipital pole fits.(1)

1.7.2. CEREBELLUM

The greatest portion of the hindbrain is called the cerebellum, or tiny brain. It is located behind the medulla and pons in the posterior cranial fossa. It is an infratentorial structure that regulates the body's voluntary movements. (2) The cerebellum is made of the vermis, a middle region, and two cerebellar hemispheres. The vermis is positioned deeply in the valley



of the cerebelli, a median groove on the inferior surface, between the cerebellar hemispheres. The falx cerebelli partially fill the vallecula. (1)

FIG:-1.2. Median section through brainstem and cerebellum

1.7.3. DIENCEPHALON

The diencephalon is an intermediate structure that is mostly concealed from view from the outside of the cerebrum because of its embedding. Most of the third ventricle is made up of its hollow. The diencephalon is categories into dorsal and ventral sections by the hypothalamic sulcus, which runs from the cerebral aqueduct to the interventricular foramen.(2) The diencephalon is composed of the thalamus and epithalamus superiorly, as well as the inferior hypothalamus and subthalamus. (1)

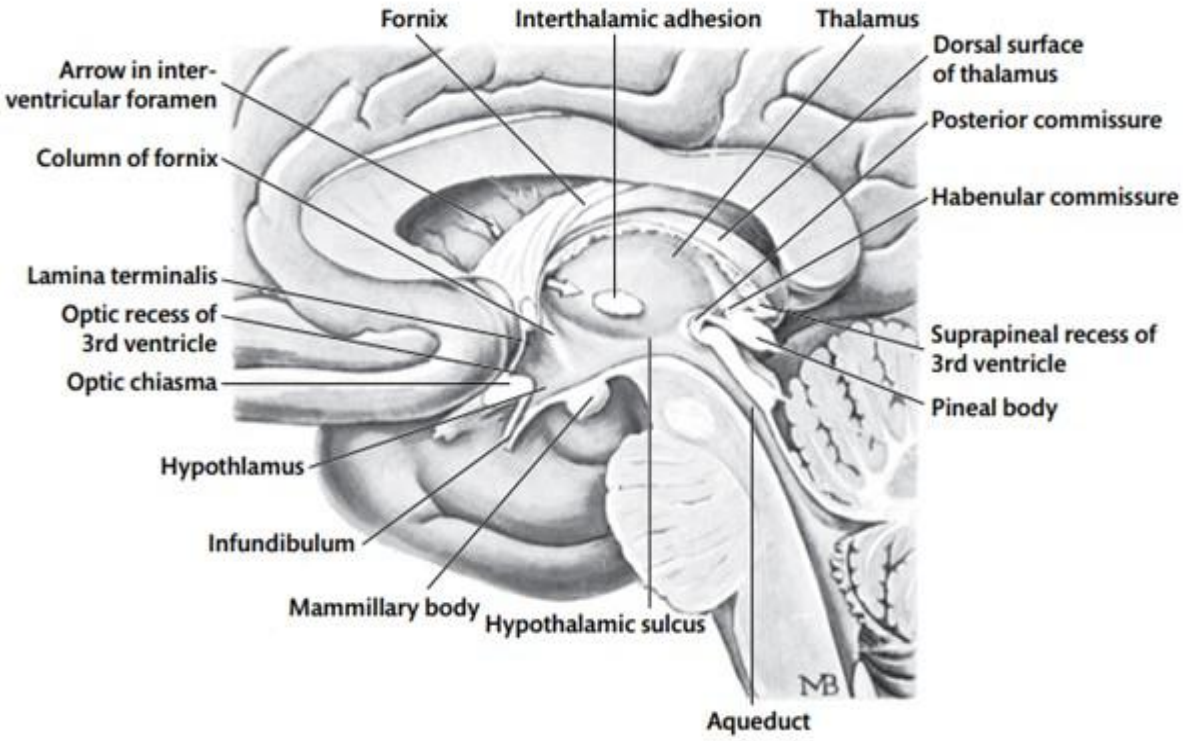


FIG:-1.3.Median section through the brain to show parts of diecephalon

1.7.4. THALAMUS

The thalamus, also called as the Greek inner chamber, is a vast mass of grey matter with transverse, vertical, and anteroposterior diameters of 4 cm each. It lies in the middle region of the lateral ventricle and on the lateral wall of the third ventricle. It has superior, inferior, medial, and lateral surfaces in addition to anterior and posterior ends. The posterior border of the interventricular foramen is made by the thin anterior end with anterior nucleus. The pulvinar is the term for the enlarged posterior end. It protrudes above the middle and lateral geniculate bodies, moreover the brachium-containing superior colliculus. (2)

The superior surface consists of a medial extra ventricular component covered by the 3rd ventricle's tela choroidea and a lateral ventricular section forming the central part of the lateral ventricle. This is bordered medially by the habenular stria (stria medullaris thalami), laterally by the thalamostriate vein, the stria terminalis, and the caudate nucleus. (2)

The hypothalamus and subthalamus support the inferior surface. The posterosuperior section of the third ventricle's lateral wall is created by the medial surface. There exists an interthalamic adhesion connecting the medial surfaces of two thalami. The lateral surface forms the medial border of the internal capsule’s posterior limb. (2)

HYPO THALAMUS

Below the hypothalamic sulcus, the hypothalamus comprises the third ventricle's lateral wall. The mammillary bodies and infundibulum, two surface of the hypothalamus, are visible in the interpeduncular fossa on the inferior surface of the brain.The hypothalamus extends lateral to the internal capsule's bottom portion. It is continuous inferiorly with the midbrain's tegmentum, with no demarcation line. The hypothalamic nuclei are categorized into three groups:

1. The three groups are anterior or preoptic, middle or tuberal, and posterior or mamillary.

SUB THALAMUS

The subthalamus, located rostral to the midbrain's tegmentum and lateral to the hypothalamus, receives efferent fibers from the globus pallidus, with most returning to the globus pallidus.(1)

1.8 ARTERIES OF THE BRAIN.

The brain is facilitated by two vertebral arteries and two internal carotid arteries. The foramen magnum is where vertebral arteries enter the skull .The internal carotid artery passes through the superior portion of the foramen lacerum and the carotid canal in the skull. After that, it meanders into the cavernous sinus and punctures the sinus's dural ceiling. It splits into its terminal branches, the cerebral arteries middle and anterior, directly lateral to the optic chiasma and inferior to the anterior perforated substance.(1)

1.9 BLOOD SUPPLY

The vermis is located in the valley of the cerebelli , a median furrow on the inferior surface, between the cerebellar hemispheres . The falx cerebelli partially fill the vallecula. The anterior inferior cerebellar is a branch of the basilar artery and the superior cerebellar is one of its branches . The branch of the vertebral artery that is posterior inferior cerebellar artery. Veins drain into adjacent venous sinuses. (2)

1.10 Cranial nerves

Twelve pairs of cranial nerves, some mixed, some motor, and some sensory, emerge from brain nuclei located on the inferior surface, names and numbers are:-

I – The Olfactory

II – Optic

III – Oculomotor

IV – Trochlear

V – Trigeminal

VI – Abducent

VII – Facial

VIII – Vestibulocochlear (statoacoustic)

IX – Glossopharyngeal

X – Vagus are the main sensory organs.

XI – Accessory

XII – Hypoglossal

1.11 Comunication of the nerves to brain

I and II to the forebrain.

II and, IV to midbrain.

V, VI, VII and VIII to the pons.

IX, X, XI and XII to the medulla oblongata. (4)

The brainstem contains nuclei of CN III to XII both motor and sensory nuclei for CN IX, X, and a section of the medulla are located at this point sensory centers for CNs VIII and V. Three important sensory nuclei are situated near the level of the pontomedullary junction : the cochlear and vestibular nuclei of CN VIII, as well as a portion of the sensory nucleus for CN V.There are three significant nuclei in the pontomedullary junction: CN VI, VII, and VIII. Lastly, the nuclei for CN III and VI are located in the midbrain tegmentum. In reality, CN IV arises dorsally at the pons-midbrain junction (between the quadriceps' inferior collicus and anterior medullary velum.(5)

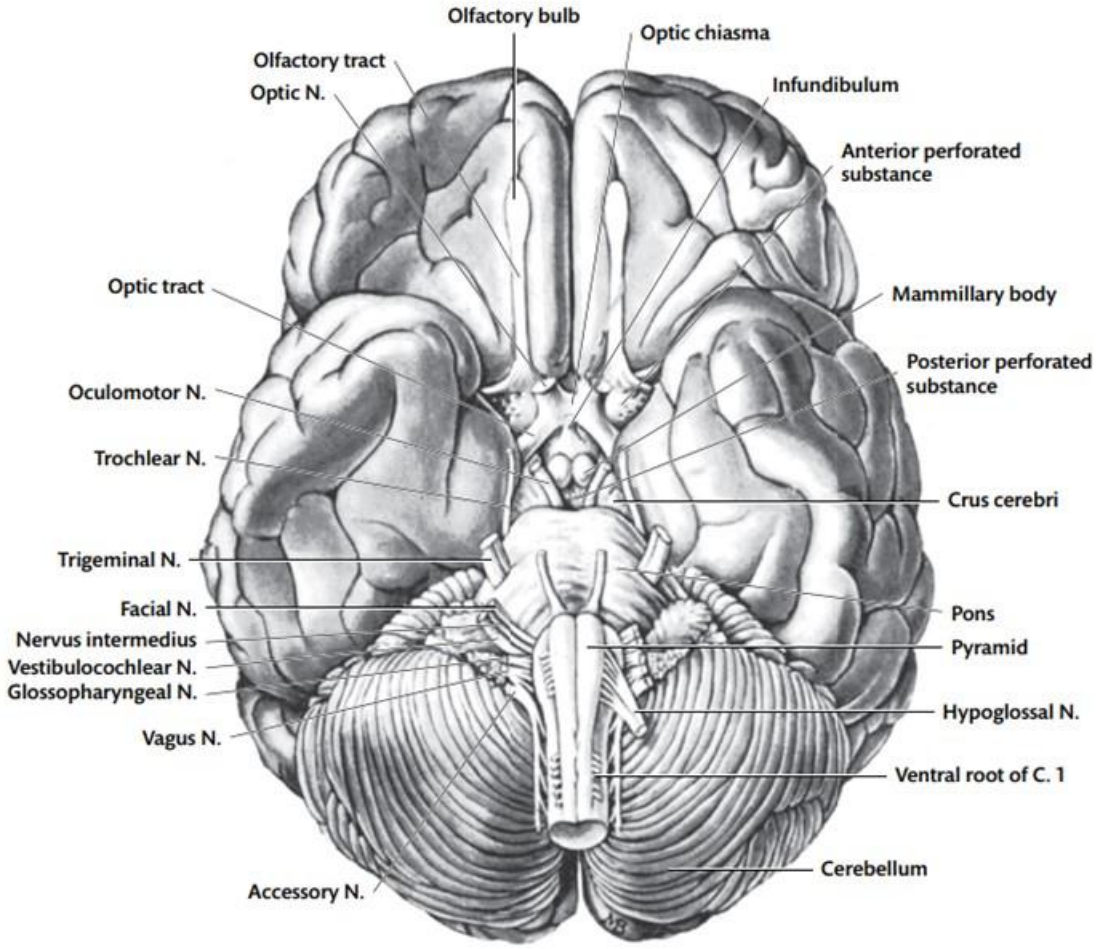


FIG:-1.4. The base of the brain and cranial nerves.

1.12. BRAIN STEAM

The brainstem, comprising the mesencephalon, pons, and medulla, is a crucial anatomic component that comprises numerous significant cranial nerve nuclei, tracts, and fibers. Vital processes such as respiration, cardiac rate, BP, swallowing, movement, and sensation of the face, lips, tongue, and extremities are all controlled by the brainstem. (6)

The brainstem contains both gray and white matter. The brainstem's gray matter, or neural cell bodies, are distributed in clumps and clusters to create the reticular formation, pontine nuclei, and cranial nerve nuclei. The fiber tracts, or axons, of neuronal cells that rise from the spinal cord and peripheral nerves to reach the highest areas of the brain through sensory pathways, comprise the white matter. (7)The gyri (Greek circles) that make up the cerebral cortex are seprate from one another by sulci. Approximately two-thirds of the cortex's total

surface in the human brain which is believed to be more than 2000 cm2 is concealed from view by the sulci. (2) With its complexity, the brainstem's internal structure is arranged systematically and is divided into three longitudinal laminae that make up its tectum, tegmentum, and basis. The pons houses the superior medullary velum, the medulla oblongata houses the inferior medullary velum, and the midbrain houses the quadrigeminal plate. There are no tracts, reticular formation, or cranial nerve nuclei. (7)We find the respiratory and vasomotor centers in the medulla oblongata. Oculomotor and trochlear are located in the midbrain. The trigeminal, abducent, facial, and statoacoustic nerve nuclei are located in the pons, whereas the medulla contains the nuclei of the final four cranial nerves: the glossopharyngeal, vagus, accessory and hypoglossal nerves. (2)

The pyramidal pathway (corticospinal and corticobulbar tracts) is located in the base, which is the ventral lamina. It is biggest at the pons due to the existence of several nuclei (pontine nuclei), which receive many fibers that extend to establish the pontocerebellar route with the cerebellum. This lamina represents the medulla pyramids, with the pes cerebri in the midbrain serving as the foundation. Tagmentum is split into two layers and is placed between the basis and tectum. The dorsal layer houses every single cranial nerve nucleus responsible for somatomotor and general sensory functions. The ventral region contains supplementary motor nuclei, including the substania nigra, red nucleus (midbrain), and lower olivary nucleus (medulla), located near the basis. The reticular structure encircles the running tracts, also known as the lemniscus or sensory tracts, which span the remaining tegmentum. (7)

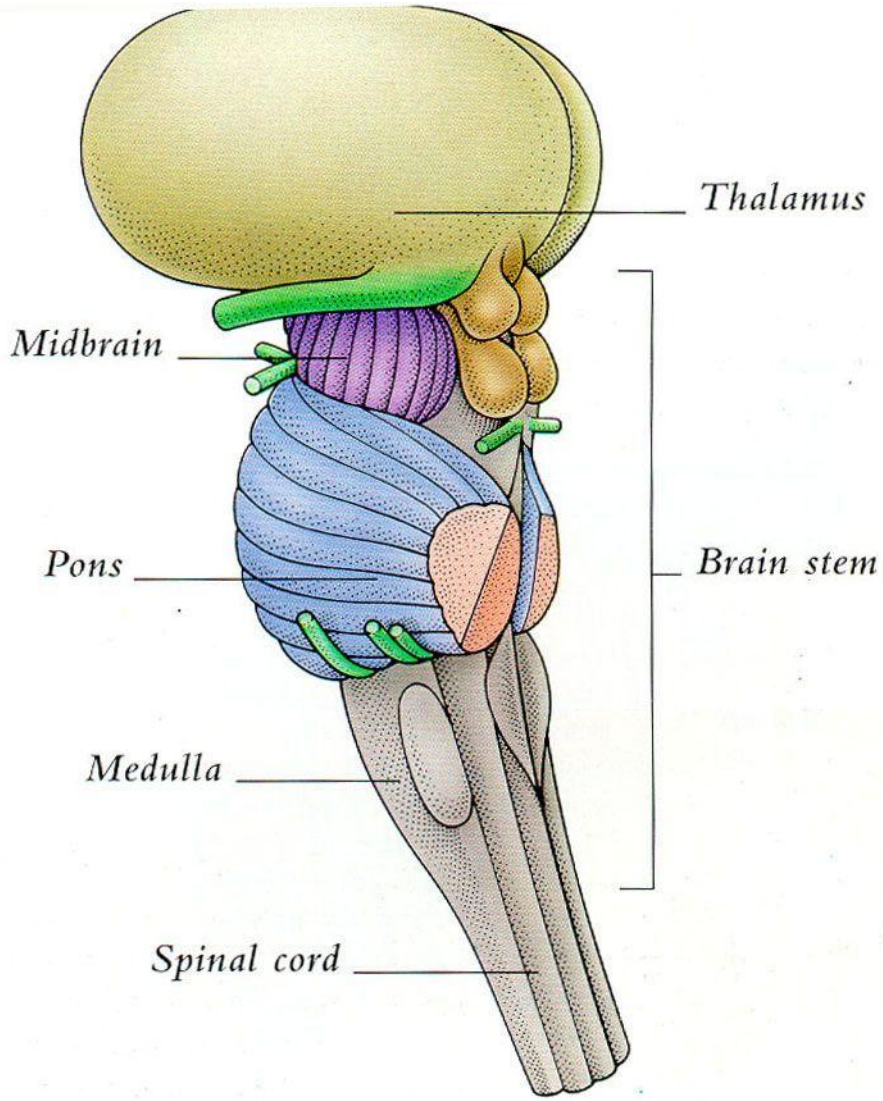


Fig:- 1.5. Lateral view of the brainstem

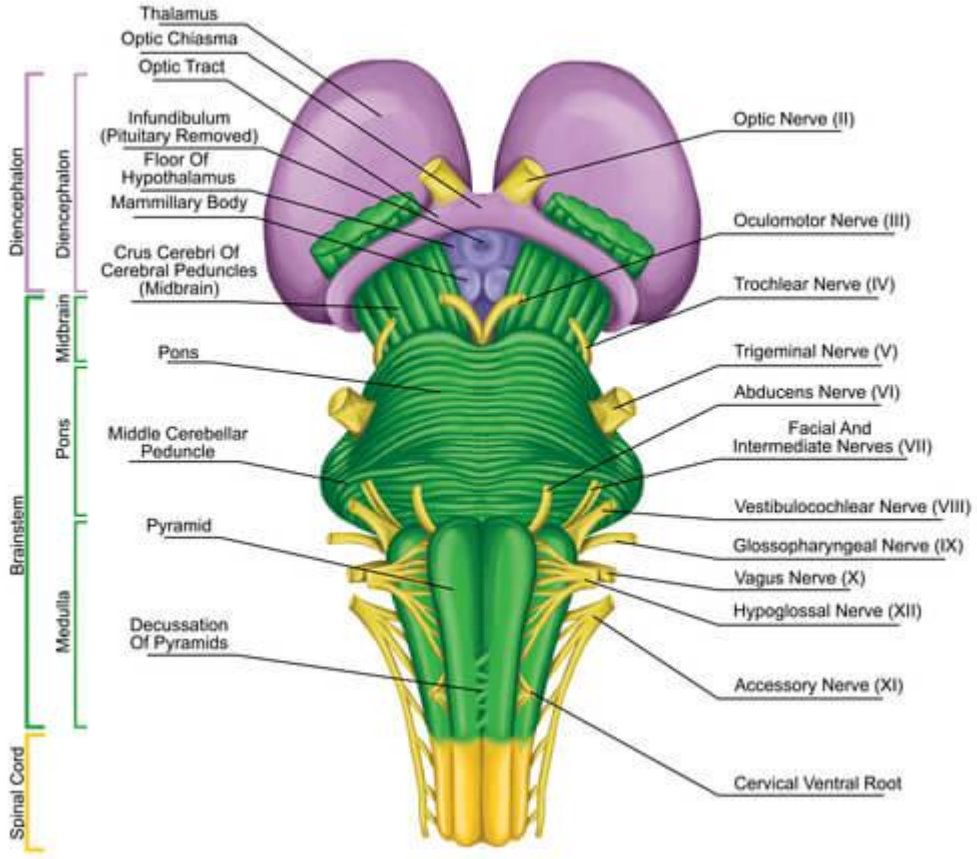


Fig 1.6. Anterior surface of brainstem

1.13. BLOOD SUPPLY

The vermis is situated between the cerebellar hemispheres in the valley of the cerebelli, a middle furrow on the inferior surface. The vallecula is partially filled by the falx cerebelli. The basilar artery has a branch called superior cerebellar, a branch of the basilar artery is the anterior inferior cerebellar. The posterior inferior cerebellar artery is the branch of the vertebral artery. Veins empty into venous sinuses that are nearby. (2)

1.14. Arterial supply to brainstem:-

The brainstem is supplied by various arterial trunks including the anterior and posterior spinal arteries, posterior inferior cerebellar artery, anterior inferior cerebellar artery, superior cerebellar artery, posterior cerebral artery, and anterior choroidal artery.

1.15. Arterial supplying to the midbrain:-

The midbrain is supplied by five arterial trunks: the anterior choroidal artery, which arises from the carotid system, The middle rami of the interpeduncular arteries, originating from the posterior cerebral artery, is a crucial part of the brain's circulation, the posteromedial choroidal arteryis the vital blood vessel, the collicular artery, and the superior cerebellar artery (primarily the medial branch).

1.16. Arterial supplying to the Pons:-

The pons receives blood from various arterial trunks, including the basilar artery, superior cerebellar artery, vertebral artery, and anterior inferior cerebellar artery, forming the lateral medullary fossa.

1.17. Arterial supplying to Medulla:-

The medulla is supplied by the anterior and posterior spinal arteries, vertebral arteries, and posterior inferior cerebellar artery, which give birth to the lateral medullary fossa.

1.18. BRAINSTEM EMBRYOGENESIS

The prosencephalon, mesencephalon, rhombencephalon, and myelon are the four main transverse parts (CNS). Without further segmentation, the mesencephalon and myelon, respectively, comprise the midbrain and spinal cord. The midbrain and spinal cord are formed from the mesencephalon and myelon, respectively, without any additional segmentation. The metencephalon, which forms the pons and houses the rostral half of the fourth ventricle, and the myelencephalon, are crucial structures in the brain. The medulla, which includes the caudal half of the fourth ventricle, are further divisions of the rhombencephalon. The middle foramen of Magendie is created as rhombencephalic roof plate is punctured in the midline on the fiftyth day of gestation. At the angles along the sides two identical holes can be found on the rhomboid that develop Luschka's lateral foramina. Renal cells develop in the rhombic borders and the cerebellum forms by either staying dorsally or vestibular, auditory, and migrating nuclei ventrally joining the inferior olivary by way of the tegmentum.superior oliveirinal and medulla nuclei pons nuclei or into the pontis base to produce the corticopontocerebellar relay nuclei route. (5)

1.19. ANATOMY OF MID BRAIN

The brainstem includes the midbrain. It is the slender portion that connects the diencephalon to the pons by passing through the tentorial notch. (1) It is made up of clusters of cell bodies and nerve fibers (tracts) that join the spinal cord and lower brain regions with the cerebrum. The ascending and descending nerve fibers use the cell bodies as relay stations. (4) The midbrain houses the nuclei of cranial nerves III, IV, and a portion of V (sensory). The caudal midbrain is where the ascending superior cerebellar peduncles (HURLEY) The only brain region that is not further segmented is the midbrain, or mesencephalon. (7) The midbrain is connected to various structures, including the parahippocampal gyri, optic tracts, and geniculate bodies, and is also connected to the corpus callosum and pineal body. (2) Gray matter reaches the fourth ventricle and the superior medullary velum from the upper border of the midbrain via the back side of the third ventricle's floor. (8)

1.20. BLOOD SUPPLY

The basilar artery branches provide the majority of the blood flow. In addition, it gets nourishment from the arteries that follow.

1. Posterior cerebral

2. Superior cerebellar

3. Posterior cummunicating

4. Anterior choroidal

1.21. SYNDROMES

WEBER SYNDROME

Weber syndrome is a condition characterized by an infarction of the oculomotor nucleus and cerebral peduncle in the ventromedial midbrain due to blockage of the paramedian posterior cerebral artery

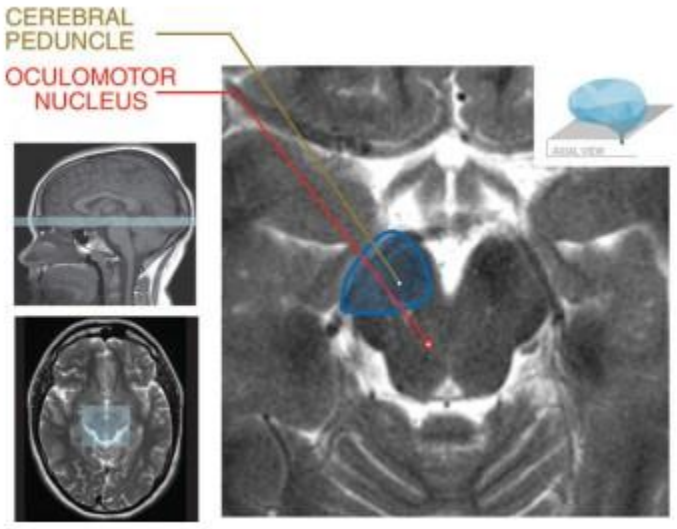


FIG:- 1.7 The 1.5T axial T2 weighted image (blue) depicts the Weber Syndrome area near the base of the midbrain.

BENEDIKT SYNDROME

The posterior cerebral artery's branches that supply the oculomotor nerve's fascicles and the red nucleus are occluded, resulting in Benedikt syndrome, also known as paramedian midbrain syndrome.(8)

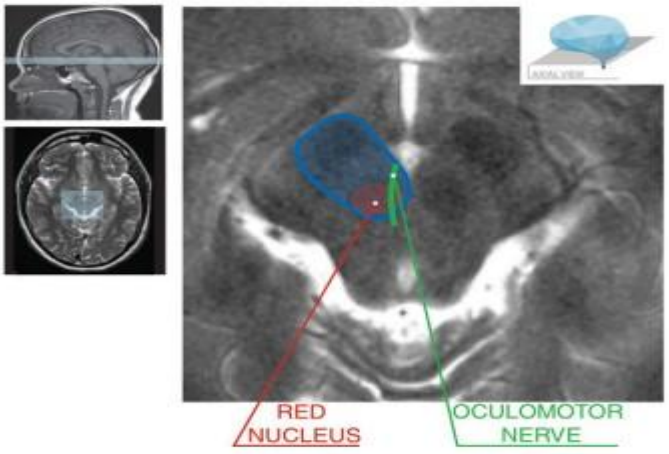


Fig 1.8. the Axial T2 weighted image (1.5T) at the level of the midbrain shows the blue surface involved in Benedikt Syndrome.

CLAUDE SYNDROME

Blockage of small perforating branches of the posterior cerebral artery, affecting the medial part of the red nucleus, the third cranial nerve nucleus, and the superior peduncle of the cerebellum, the dorsomedial aspect within the midbrain is infarcted, resulting in Claude syndrome.(8)

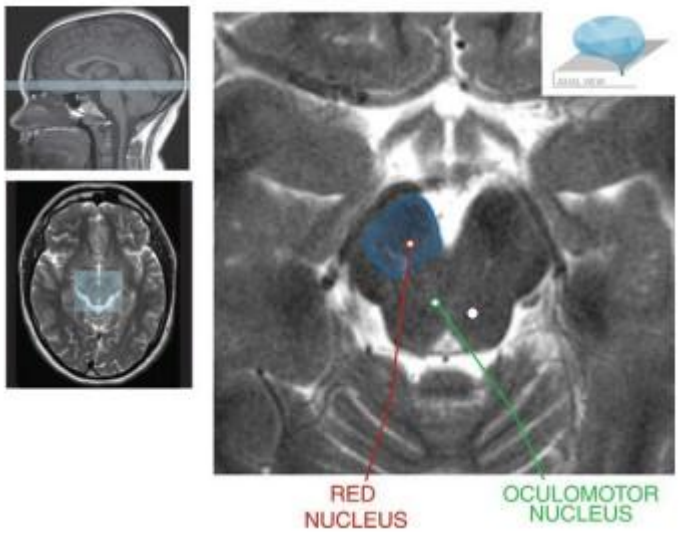


Fig:- 1.9. The axial T2 weighted images (1.5 T) at the level of the midbrain shows the blue area involved in Claude Syndrome

PARINAUD SYNDROME

A space-occupying lesion in the posterior commissure or pineal area compresses the tectal plate close to the extent of superior colliculus, resulting in parinaud syndrome (also known as dorsal midbrain syndrome). (8)

NOTHNAGEL SYNDROME

Nothnagel syndrome is caused by a tumor or infarct in the superior cerebellar peduncle, resulting from the expansion of a lesion within the quadrigeminal plate. (8)

1.22. PONS

The metencephalon is also known as pons (Latin bridge), is a 2.5 cm long The structure connecting the medulla oblongata's cranial end to the midbrain's cerebral peduncles. Here are the cranial nerves V, VI, VII, and VII I linked The entity is connected to Clivus anteriorly,

divided by the basilar artery, the middle cerebellar peduncle on the side, and to the fourth ventricle's posterior. The ventral and dorsal surfaces make up the pons, The basilar artery is lodged in a vertical basilar sulcus seen in the middle plane, In the lateral direction the surface and the middle cerebellar peduncle are continuous. (2) The pneumotaxic and apneustic centers for controlling respiration are located in the Pons. The brachium pontis, also known as the middle cerebellar peduncle, is formed when axons from pontine nuclei unite. Pons forms the neural circuit that links the cerebral cortex and cerebellum. (3)

At the point where the peduncle and pons join, the trigeminal nerve is linked to this surface. Pons is divided into superior and inferior borders, Crus cerebri are linked to the superior border. It also shows the III and IV nerves. The inferior boundary is located where the pons and medulla converge. At this border are the VI, VII, and VIII nerves. (2)

The pons' anatomical structure is different from the cerebrum's in that the nerve fibers are surface-level while the cell bodies, or grey matter, are deeply buried. (4) The auditory pathway that aids in the localization of sound includes the trapezoid body, which is also located in this area. (8)

1.23. BLOOD SUPPLY

The pontine arteries supply blood to the pons and other regions of the brain, a group of tiny blood vessels that split off at right angles from the basilar artery on either side. (2)

1.24. SYNDROMES

Marie-Foix Syndrome

Occlusion of perforating branches of the anterior inferior cerebellar artery and basilar artery causes infarction of the lateral pons and middle cerebellar peduncle the vestibulocochlear and facial crainal nerve nuclei along with the corticospinal, spinothalamic, and cerebellar tracts, are impacted. (8)

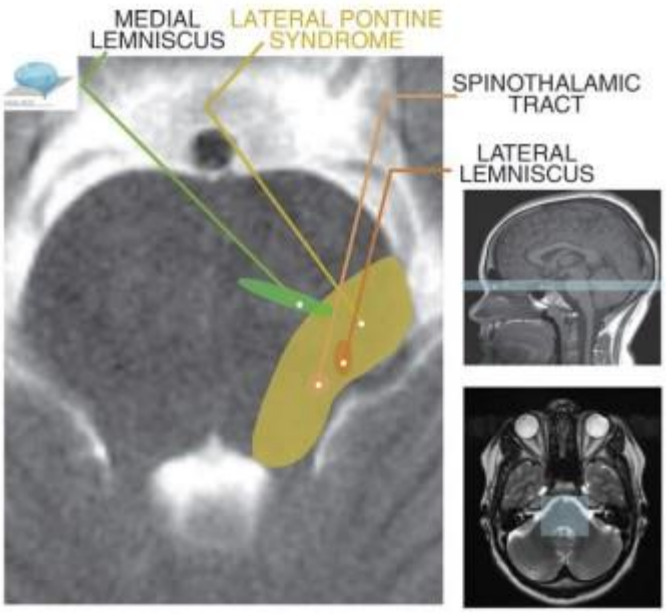


FIG:-1.10. The axial T2 weighted image (1.5T) of the pons shows the area involved in Marie-Foix Syndrome.

FOVILLE SYNDROME

It is caused by a pons infarct that affects the middle lemniscus, middle longitudinal fasciculus, paramedian reticular growth, corticospinal tract, and facial and abducens nerve nuclei. (8)

Locked -in – syndromes

A disorder known as locked-in-syndromes motor paralysis affecting each of the four extremities' voluntary muscles while preserving awareness and consciousness. In contrast, Takayasu arteritis (TA) is a systemic inflammatory illness that affects the aorta and its branches, among other big arteries. (9)

Facial colliculus syndromes

Fibers from the 7th cranial nerve's motor nucleus loop over the abducens nucleus to produce the face colliculus, an elevated region. Because of damage to the medial longitudinal fasciculus, paramedian pontine reticular formation, facial nerve fibers surrounding the abducens nerve nucleus, and the abducens nerve nucleus itself. (10)

1.25. MEDULLA OBLANGATA

The conical, whitish structure that extends inferiorly from the pons is called the medulla oblongata and at the foramen magnum connects to the spinal cord. The ventral surface of the medulla is divided into the right and left halves by a median fissure. (1)

The bottommost region of the brain is known as the medulla oblongata. It continues downward as the spinal cord and is located below the pons. The spinal cord's ascending and descending pathways primarily follow the path formed by the medulla. It also contains a large number of key centers that regulate the essential operations. (3)

It extends decending to the foramen magnum and is situated in the anterior region of the posterior cerebral fossa. It has a connection to the cerebellum's vallecula posteriorly and the clivus and meninges anteriorly. The medial lemna fills the infratentorial space, along with other hindbrain regions. (2)

The medulla oblongata, which consists of a ventral section and a dorsal tegmentum, transmits data from the spinal cord to the brain. The pyramids and the olives are situated in the ventral region. A component of the olivocerebellar system, the nucleus of the inferior olive plays a role in cerebellar motor learning. The nucleus of the superior olive has a part in hearing. The glossopharyngeal (IX), vagus (X), accessory (XI), and hypoglossal (XII) the nuclei of the cranial nerve are found in the dorsal tegmentum, along with The white matter tracts, including the medial lemnisus, medial longitudinal fasciculus, spinothalamic tract, central tegmental tract, and spinocerebellar tract, continue. (8)Corticospinal tract begin in the cerebral cortex, travel via the pons, cerebral hemispheres, and crura cerebri before ending up in the medulla oblongata's pyramid. The pyramidal fibers in the upper medulla are located on the ventral aspect, which explains the external surface pyramid. The lateral corticospinal tract is formed by most of the fibers crossing in the motor decussation of the lower medulla. The tracts that corticospinal fibers form after passing through the pyramid are known as pyramidal tracts. (1) The vasomotor system governs heart rate and blood pressure, the respiratory center maintains the rhythmic pace, deglutition controls the pharynx and esophagus, and vomiting involves GI tract inflammation salivary nuclie regulate saliva.(3)

1.26. Blood supply

A supply route for the entire medial section of the medulla oblongata is the anterior spinal artery.The posterior inferior cerebellar artery supplies the posterior-lateral region of the medulla.(2)

1.27. SYNDROMES

Wallenberg syndrome

The wallenberg syndrome is an uncommon condition that affects the medulla oblongata, resulting in ipsilateral orofacial area and counter-lateral body cross loss of pain and temperature perception. (11)

Dejerine syndrome

It is brought on by a medial medulla infarct that affects the hypoglossal nerve nucleus due to the blockage of the anterior spinal artery or tiny perforating branches of the vertebral or proximal basilar arteries. The syndrome results in ipsilateral hypoglossal palsy, contralateral paralysis, and hemisensory impairment. (8)

1.28. ABOUT MRI MACHINE

With its excellent spatial and temporal resolution and high soft-tissue contrast resolution, magnetic resonance imaging is a complete diagnostic technique.(12) MRI, a crucial diagnostic tool, has seen significant speed-ups in recent years due to parallel imaging, temporal encoding, and compressed sensing, which accurately recover missing k-space data..(13) Images are created using three various types of coils and the magnetic fields they produce. Although it could possibly be a permanent magnet, this is most frequently a superconducting electromagnet. This is supplemented by a coil that produces the radiofrequency electromagnetic field, or "RF field." Lastly, there are the imaging gradient coils, also known as "the gradients," which are in charge of producing the spatial-encoding magnetic fields. These coils, and the way the fields they generate interact with matter, are crucial to the MRI machine's ability to make images. (14)

1.29. Principle

Basically There are two primary methods for explaining the fundamentals of MRI: classically and through quantum mechan Classical theory, credited to Sir Isaac Newton, offers a

mechanical explanation for the universe and MRI, utilizing concepts like mass, spin, and angular momentum on a large scale. Quantum theory, credited to Max Planck, Albert Einstein, and Paul Dirac, operates on a subatomic scale, explaining all physical principles, despite classical theory being used for large-scale explanations.

MR-active nuclei align their rotation axis with an applied magnetic field due to their angular momentum and electrical charge. They automatically acquire a magnetic field, denoted by a magnetic moment, with vector properties for size and direction. The vector sum of all the magnetic moments of the nucleus's protons is the nucleus's total magnetic moment. Important examples of MR-active nuclei, together with their mass numbers are listed below: • 1H (hydrogen) • 13C (carbon) • 15N (nitrogen) • 17O (oxygen) • 19F (fluorine) • 23Na (sodium) Protium, a hydrogen isotope, is the most commonly used MR-active nucleus in MRI, consisting of a single proton and lacking neutrons . Alignment is demonstrated in classic theory by the direction of the magnetic moments of spins (hydrogen nucleitQuantum theory utilizes the energy level of spins or hydrogen nuclei to illustrate alignment . A limited number of energy level are created when the protons in hydrogen nuclei couple with the external magnetic field B0 (also known as the Zeeman interaction). There are just two conceivable energy levels for hydrogen nuclei.(15)

1.30. PRINCIPAL OF MRI

1.PATEINTS ENTERS THE BORE MAGNET

In the patient body after an external magnetic field is applied, all protons align randomly and become aligned parallel to the external magnetic field along the z-axis , forming longitudinal magnetization.

2. Intitation of the RF pulse

RF pulse energy pickup by the precessing proton to go high energy level and precess in phase. As a result the longitudinal magnetization flips 90 deg. And form the transverse, magnetization.

3. Received the MRI signals

After Rf pulse is stopped the transverse magnetization relaxes and then a signal is induced in the RF pulse.

4. Formation of image

By the complex mathematical process like fourier transformation MR signals is received and transform into image. (16)

1.31. Instrumentation

The system includes a powerful magnet, shim system for uniformity, gradient system for linear strength, and an RF transmission system for electromagnetic radiation generation and transmission.

The system includes RF receiver coils for patient signal detection, a computer system for parameter input and image display, and a computer subsystem for coordinating RF pulse utilization and data reconstruction. (15)

1.32. COMPONETNS OF MRI

The four major parts of an MRI system are the radiofrequency (RF) coils, gradient coils, the main magnet, and computer systems that interface and operate each part. To acquire an MR image, follow these four simple points:

(1) position of the patient in a uniform magnetic field produced by the components of the MRI

(2) use an RF pulse to shift the equilibrium magnetization vector

(3) gather the signal as the magnetization vector returns to equilibrium; and

(4) use the computer's signal processing algorithms to turn the signals into images. (12)

1.33. MAGNETS

A cryostat-enclosed bath of liquid helium has a number of coils wound on a cylindrical shape to generate a superconducting magnet. The coiled wires made of niobium-titanium alloy become superconducting at temperatures lower than 10 Kelvin (−263 °C). By immersing The system is filled with liquid helium, which is thermally insulated by a cryostat to minimize helium boil-off. this temperature is reached .The superconducting coils are cooled to −269 °C by the cryostat's helium when the magnet is first turned on. The next step, known as

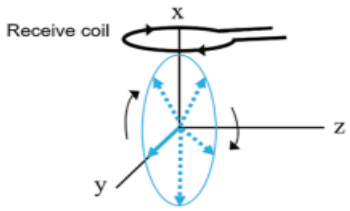
"ramping up," involves an external power source supplying current to the coils. The magnetic field intensity can be sustained by the current passing through the superconducting coils as long as the magnet is cooled enough. On the release of the liquid helium from the system, the magnet warms up and loses its superconducting ability. In case of a fire or a metallic object entering the magnetic field, it poses a threat to the patient or equipment, the MRI staff may initiate this process, known as a "quench," or it may be the result of technical malfunctions. Tesla (T) and Gauss (G) are the units used to measure the strength of Bo(magnetic field). Ten thousand G is similar to one Tesla. A 1.5-T magnet's primary magnetic field has a strength of about 30,000 times that of the earth's magnetic field, which is equivalent to 0.5 G. (12)

1.34. GRADIENT COILS

Gradient coils are employed in MRI systems to encode spatial information by providing a modest spatially dependent fluctuation in the Larmor frequency and by adding a relatively minor component to the B0 field that varies linearly with position. Spatial gradients of about 40 mT/m (or 4 G/cm) are typical in today's systems, while some more current commercial systems can reach as high as 80 mT/m. A 40 mT/m gradient set yields a maximum magnetic field strength of 10 mT (100 G). at the boundaries of the imaging field-of-view (FOV), assuming a 50 cm FOV. The gradient coils produce fields that are roughly three orders of magnitude stronger than the RF coils' fields, but between two and three orders of magnitude weaker than the static magnetic field. (14)

1.35. RADIOFREQUENCY COILS

Radiofrequency coils are crucial hardware in MRI, transmitting the RF field to excite proton spins in the body and receiving MRI signals from the body . Regarding signal -to- noise ratio (SNR) signal homogeneity, and image resolution ,RF coils are crucial to the quality of MR images .RF coils however ,are also linked to the possibility of image distortions and RF heating, which could result in patient burns. RF coils can be categorized into transmit coils, receive coils, and transmit-receive coils.



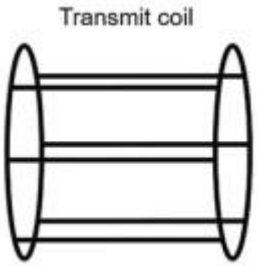


FIG:-1.11. RECEIVER COIL **FIG:-1.12. TRANSMIT COIL**

Clinical RF coils, traditionally rigid with a hard external casing, are now increasingly popular in MRI due to their ability to image a wide range of body parts, making them a more versatile alternative to rigid coils. (17)

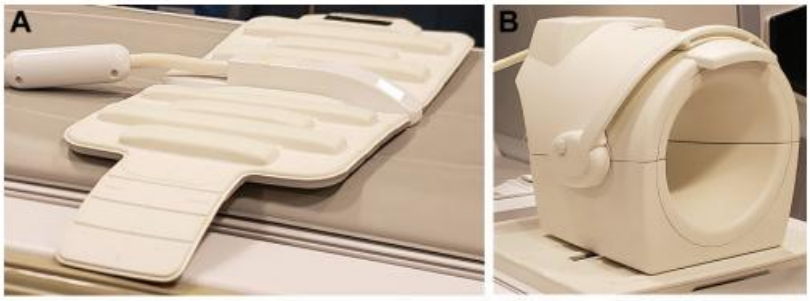


FIG:-1.13 (A)Photograps shows a 16- channel flexible coil (B) an eight knee coil.

1.36. MAGNETIC SUSCEPTIBILITY

Magnetic susceptibility refers to a substance's ability to be influenced by external magnetic fields, affecting the nuclei of an atom, with paired electrons being more protected than unpaired electrons.,there are three types of magnetic filds paramagnetism, diamagnetism and ferromagnetism.

Paramagnetism

Paramagnetic substances, containing unpaired electrons, create a magnetic moment, which aligns with external magnetic fields, increasing the local magnetic field.

Diamagnetism

Diamagnetic substances lack a net magnetic moment due to the zero sum of electron currents due to their motion.

Ferromagnetism

A magnetic field can cause strong attraction and alignment when a ferromagnetic material comes into contact with it. Ferromagnetic substances remain magnetic, are permanently magnetized and subsequently become permanent magnets.

1.37 Sequences

Spin-echo pulse sequences are a fundamental method in MRI, used to generate T1, T2, or proton density weighted images. 90° excitation pulse following the 180° rephasing pulse followed by an echo. (16)

T1 weighting

When an image is T1 weighted ,the contrast is mostly determined by the variations in T1 recovery durations between water and). The TR regulates the amount of recovery for each vector prior to the slice being activated by the subsequent RF excitation pulse. The TR needs to be brief enough so that neither the vector in fat nor the vector in water has enough time to fully retrun to B0 in order to accomplish T1weighting. The longitudinal magnetization of the water and fat vectors entirely recovers to B0 if the TR is too long. When it does, both tissues have finished their T1 recovery, and the variations in their T1recovery durations are not apparent .Anatomy and pathology are displayed on T1 weighted images following the use of a contrast agent.(15)

T2 weighting

T2 weighted images highlight pathology best due to exaggerated distinctions in tissue T2 decay times, resulting in brighter images with increased water content.

PD weighting

A Proton density wighted image is one in which the primary factor producing image contrast is variations in the quantity of mobile hydrogen nuclei per unit volume of tissue. The impacts of T1 and T2 contrast are reduced to allow proton density contrast to take center stage in order to achieve PD weighting. Long TRs reduce T1 contrast by allowing the vectors in fat and water to fully regain their longitudinal magnetization. PD-weighted images are utilized to assess anatomy and disease because a brief TE reduces T2 contrast by not giving the vectors in fat or water enough time to dephase. (15)

Diffusion weighted imaging (DWI)

Dffusion refers to the movement of molecules in the extracellular space due to random thermal motion, confined by boundaries like ligaments, membranes, and macromolecules. Diffusion restrictions can be directional, depending on tissue structure, and can also be restricted in pathology The apparent diffusion coefficient (ADC) is a crucial intrinsic contrast parameter that measures the net displacement of molecules across the tissue area per second Tissues with free diffusion exhibit a high ADC, while those with restricted diffusion have a low ADC. (15)

Susceptibility weighted Imaging (SWI)

SWI utilizes variations in magnetic susceptibility among tissues to create image contrast, often using gradient-echo sequences and a long TE to enhance these differences. (15)

Siemens Magnetom Avanto 1.5T MRI System

High performance technology is delivered by Siemens in the Magnetom Avanto 1.5T, which is required for the most demanding MRI scans. The remarkable visual quality and detail are made possible by the high-resolution technology. A level of picture information that was not gain with previous MRI system versions is made feasible by the high speed and great resolution. You will be able to diagnose more accurately with better photographs.

Patients will experience breakthrough comfort with the Magnetom Avanto 1.5T. With its noise reduction technology, decibel levels can be lowered by up to 97%. In order to make this technology accessible to the majority of patients, the table is also lowered to the floor.

Patients can enter and exit the scanner more easily with the help of this table. The wide tube design and feet first entry of this MRI machine assist lower the claustrophobia risk. The exam time to finish the scan is also shortened by the high speed technology. Your patients will experience the level of comfort that the Magnetom Avanto 1.5T should provide.

Siemens Magnetom Avanto 1.5T Product Description

- Complete picture matrix technology
- Most patients can access the scanner because of the low table height.
- Includes the industry's strongest gradient as standard—the SQ-engine.
- Even patients with severe illnesses can experience great levels of relief because of ultralight coils.
- Employs the maximum SNR (18)

CHAPTER -2

AIM: –

EVALUATION OF THE BRAIN STEM ON THE BASIS OF AGE, GENDER, BMI BY USING 1.5 TESLA MRI

OBJECTIVES:-

To determine the relation between age, gender, and BMI with AP diameter of midbrain , pons, and medulla junctions by using the technique called linear measurements on MRI brain examination.

NEED OF THE STUDY-

- The normal range given in this study can be acknowledge for the assessment of physiological/pathological changes in brainstem.
- To evaluate the changes in brainstem according to BMI.
- It helps to evaluate the accurate size of the brainstem according to the age, gender, and BMI.
- Age-related changes, sex differences, and BMI to evaluate pre-diagnosis neurological disorder.

CHAPTER -3

REVIEW OF LITERATURE

3.1.Xiaoyi Liu et.al (2024) Conduct a study on "Deep Learning in Medical Image Classification from MRI-based Brain Tumor Images " Department of Xiaoyi Liu Ira A. Fulton Schools of Engineering Arizona State University Tempe, USA. The study published in journal Which is google scholor indexed. Data was comprises 7023 images, with 2000 images without tumors, 1757 pituitary tumor images, 1621 glioma tumor images, and 1645 meningioma tumor images. The dataset is subsequently split into 0.8 for training, 0.1 for validation, and 0.1 for testing. The study based on the focuses on making predictions for brain tumor classification. Five models, including four pre-trained models (MobileNet, EfficientNet-B0, ResNet-18, and VGG16) and one new model, MobileNet-BT, have been proposed for this study. Aim of this study aim to utilize the brain tumor MRI dataset to classify four types of brain tumors: glioma, meningioma, pituitary tumors, and the absence of tumors. The result shows Four pre-trained models were tested on the brain tumor dataset, resulting in accuracies of 0.8445, 0.8659, 0.8933, and 0.9497, respectively. The new model, MobileNet-BT, which is based on MobileNetV2, achieved an accuracy of 0.9924.

3.2 Gaku Fujimoto et al. conducted the study, in 2023, the Department of Psychiatry will be implementing a model for estimating brainstem volume in healthy individuals and difuse axonal injury patients. Graduate School of Medicine, Kyoto University Japan in journal of nature portfolio with impact factor 69.504 which is PubMed indexed. The study uses T1-weighted MR images were analysed using volume measurements from 182 healthy adults of group A and B, 22 DAI patients and 60 healthy subjects, and a quantitative model based on age, sex, and intracranial volume was developed to determine the brainstem and cerebrum's usual healthy volume. The results show Age and sex differences between Groups A (18-64) and B (20-68) were negligible, there were no discernible difference in age or sex between DAI (diffuse axonal injury) patients and HCs(healthy adults). The final conclusion one the severity of damage, as indicated by the duration of posttraumatic amnesia, significantly influences the chronic-phase brainstem volume in patients with DAI., (19)

3.4 Abdalrahim Y. Mohamed et al. conducted the study on Stereological measurements of The study at El Mahdi University Sudan in 2023 utilized Magnetic Resonance Image

software to study the volume of Medulla oblongata in young adults, with an impact factor of 0.51. The study measures the volume of the medulla oblongata in 18 males and 18 females on T1 weighted image on mri using image j software. The results shows significant differences between genders .Mean volume is grater than meal volume of female and there were no any significant correlation between genders in medulla oblongata volume and BMI, size of medulla decreases by increasing age from 20 to 40. (20)

3.3 Amrutha Ranganath et al, In 2022, a study was conducted on age and gender differences in morphometric measurements of brain stem using magnetic resonance imaging in healthy Indian adults**.** at Sri Devraj Urs Medical College and University, Kolar, Karnataka India in journal of Datta Megha Institute of Medical Sciences University with an impact factor 0.166. Morphometric measurements of brain stem on 142 healthy Indian adults 82 males and 60 females on AP diameters of mid brain, pons, medulla (at pontomedullary PM and cervicomedullary CM) the study use MRI T1 sag measurements. The results show with increasing age reduction in brain stem measurements mid brain, and medulla, maximum diameter of mid brain at the age 18-30, pons at the age 40-50 and medulla at the age 20-30 and 30-40 at PM (Pontomedullary junction) and medulla at CM (Cervico medullary junction) The final conclusion is the AP diameter shows significant reduction in diameters of brain stem structures with increasing age ,there was no gender related changes in sagittal diameter of mid brain ,pons and medulla. (21)

3.4 S.T. RUIZ et al. The study examined the normative data for brainstem structures, the midbrain-to-pons ratio, and the Magnetic Resonance Parkinsonism Index**.** in 2022 at St. Olavs University Hospital, Trondheim, Norway in journal American Journal of Neuroradiology with impact factor 3.5 which is Pub MED indexed. The study uses Age, height, weight, and body mass index correlations and sex differences in brainstem measurements and The midbrain-to-pons ratio and Magnetic Resonance Parkinsonism Index were determined from midbrain and pons measurements. As well as the widths of the middle and superior cerebellar peduncles.3D T1W1 were taken on 996 subjects (537 women of the age 50 to 66 yrs.). The results show. The pons area, superior and middle cerebellar peduncle width, the midbrain-to-pons ratio, and the MRPI showed significant sex differences, but the midbrain area did not. Numerous brainstem measurements had significant very weak to weak associations between body mass index, height, weight, age, and both sexes. Age and gender-specific ranges for the brainstem measurements

were made due to age having the highest and simplest correlations, but no systematic difference in distribution caused by these factors was discovered. The final conclusion these data established to reduce the possibility of a false diagnosis in individuals with suspected brainstem atrophy undergoing neuroradiologic evaluation. (22)

3.5 Jyotindu Debnath et al., In 2022, an MRI-based morphometric study was conducted to assess normal measurements of brain stem and related structures for all ages. Department of Radiodaignosis and Imaging of Medical College in India in journal of Eleviser with impact factor 7.0 which is PubMed indexed. This study use for patients of all ages, the proximal cervical cord, middle cerebellar peduncles, and brain stem were measured linearly and at angles in T1WI axial ,sagittal images of crossectional studies of interpeduncular angle, middle cerebellar peduncle transverse thickness, cerebral peduncle transverse thickness thickness of the ventral midbrain from front to The study examines various factors such as back midbrain height, Mamillopontine distance, Pontomesencephalic angle, Anteroposterior Pons thickness, Anteroposterior Medulla thickness, and Anteroposterior Spinal Cord diameter.. The result shows most of the variables showed significantly higher mean values for men. Most of the measured variables, including the Pons, Medulla, Spinal Cord diameter, Ventral and Anterior Midbrain Thickness, and Middle and Anterior Cerebellar Pedules, exhibited a continuous and rapid increase in values from childhood until after the age of 20. The final conclusion the current study provides normative data that can be used in day-to-day practice for the brainstem and a few adjacent regions across all ages.(23)

3.6 MAHA IBRAHIM METWALLY et al. A 2021 study at Zagazig University in Egypt published in the British Institute of Radiology, referencing brainstem, cerebellar vermis, and peduncle measurements. The study uses supra and infratentorial structures divide in 6 distinction age groups (infant, child, adolescent, young, adults, middle age adult, old age) on 565 normal healthy patients(273 males and 292 females). The study uses sagittal T1 and axial T2 images were taken. The results show reproducibility on inter and intra observer measurements except transverse diameter of mid brain, AP diameter medulla at CM and PM junctions, AP diameter cerebellar vermis and thickness of superior cerebellar peduncle, gender variation shows on AP pons, medulla at CM junction and cerebellar height, age-related alterations were noted in every measurement. (24)

3.7 Kadavigere V. Rajagopal et al, In 2021, a study was conducted at the Department of radiodiagnosis to compare the morphometric evaluation of the brainstem in neurodegenerative diseases with healthy individuals. Kasturba Medical College Karnataka in the journal of Taibah University Medical Sciences with impact factor 0.392 which is PubMed indexed. the study uses the measurements of the pons, the midbrain, the ratio of the two, the upper profile of the midbrain, the thickness of the substantia nigra (SN), the width of the cerebral crus, the distance between the peduncles, and the concavity of the crus on 100 healthy subjects 50 were normal subjects (37 men and 13 females) with age 50 to 70control groups on the other hand 47 subjects with PD and PSP on T1 weighted images of sagittal, mid sagittal from axial images on MRI machine. The results show the mean anteroposterior diameter of patient with PD was abundant that of the unaffected group and PSP patients, Comparing PSP patients to other groups, the midbrain and pons areas of the patients showed the least activity, PSP patients had the lowest midbrain to pons area ratio, The middle cerebellar peduncles' mean thickness was thinner in the PD group on both the right and left sides, the SN's breadth slowly decreased in PD patients, and more so in PSP patients. In every group, the midbrain's superior convex profile was present. The final conclusion when paired with their clinical data, the morphometrics of the brain stem profile can be useful in discriminating neurodegenerative illness in older, healthy persons. (25)

3.8 G.O. DOVJAK et al. conducted the study on Normal human brainstem development in vivo: a quantitative fetal MRI study in 2021 at The Department of Biomedical Imaging and Image-Guided Therapy at Medical University of Vienna published a study in Ultrasound Obstet Gynecol 2021, with a PubMed indexed impact factor of 8.678. The study uses One observer measured the cross-sectional area, rostro caudal diameter, anteroposterior diameter, medulla oblongata, cerebellar vermis, and transverse cerebellar diameter of the midbrain, pons (basis pontis and pontine tegmentum), and the cerebellum to test for inter-rater variability, a second observer also evaluated the diameters on T2 weighted images on 161 fetuses with normal brain mid sagittal. The results shows Vermian area and gestational age show a significant quadratic connection, and all other measured parameters had a significant linear growth pattern all through the duration of the observation period, Between the second and third trimesters, the brainstem substructures showed a significant shift, with an increase in pons area and a decrease in midbrain area. The final conclusions Between 15 and 40 weeks of gestation, the fetal

brainstem's substructures develop according to a specific spatiotemporal pattern that is characterized by a relative increase in the pons and a decrease in the midbrain. (26)

3.9 In Hee Cho et al. conducted the study *on* Reduced Volume of a Brainstem Substructure in Adolescents with Problematic Smartphone Use at The Department of Psychiatry at Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea. in 2021 in the journal of J Korean acad child adolescence psychiatry with the impact factor 1.81 which is PubMed indexed. The study uses comparing the volume of the brainstem substructures in teenagers who have and don't have PSU (problematic smartphone use) we measured the volume of the midbrain, pons, medulla, and superior cerebellar peduncle (SCP), the four brainstem substructures. The impacts of age, gender, whole brainstem volume, depressive symptoms, and another factor was taken into account during the analysis of correlation, which revealed group differences on 87 adolescents Korean (12- 18) on 3T T1 weighted gradient echo. The result shows comparing the PSU group to the control group, the SCP (superior cerebellar peduncle) volume was lower in the PSU group, there was a bad correlation between the SAPS (smartphone addiction proneness scale) score and the SCP volume. The final conclusion to show that among teenagers with PSU, the volume of the brainstem substructure is altered. This finding raises the possibility that one of the neurobiological factors behind behavioural alterations in PSU is the altered white matter structure in the brainstem.(27)

3.10 Stephanie Mangesius et al. conducted the study in 2020, brainstem MR planimetric measurements at the Department of Neurology showed no significant impact of age, gender, or total intracranial volume., Medical University of Innsbruck, Austria in the journal of European Radiology with impact factor 5.02 which is PubMed indexed. The study uses to assess the impact of Total intracranial volume (TIV), gender, and age on brainstem MR planimetric data, brainstem midbrain, pons, middle, and superior cerebellar peduncle dimensions and areas, derived ratios, and the magnetic resonance Parkinsonism index (MRPI) were measured using MR planimetry on 1.5 tesla MRI machine number of subjects is 97 with age 30 to 80 yrs. on coronal T1 3D(MPRAGE). The result shows in the population relevant for the purpose of distinguishing between the diagnosis of neurodegenerative Parkinsonism, aged 50 to 80 years, no gender or age effects on planimetric measures were seen, with the exception The study found that gender and age effects on the pontine area and midbrain area were comparable after incorporating the TIV into the studies. The study concludes that brainstem-derived MRI planimetric measures are suitable for differential

diagnosis of neurodegenerative Parkinsonism without requiring adjustments for age, gender, or TIV. (28)

3.11 S.O. POLAT et al. conducted a study on The morphometric measurements of the brainstem in Turkish healthy subjects according to age and sex in 2019 at Cukurova University, Adana Turkey in a journal via media. Pl (Folio morphol) with an impact factor 1.2 which is PubMed-indexed. Brain stem measurements were performed on 263 healthy adults 158 females and 105 males including midbrain, pons, and medulla. This study uses MRI axial T2 TSE and sagT2 SE. The result shows some important differences on The vertical diameter of the pons, mid brain, and the distance between the interpeduncular fissure and the aqueduct cerebral are all important factors to consider. (males show mean brainstem ratio measurement higher), and significant differences found in MOMSJ (shortest anteroposterior diameter of the medulla at medullospinal junction) and DPMM (anterior surface of pons midway between midbrain and medulla to fourth ventricular floor) according to age in both male and female. In females, DIPFA($p=0.009$) decreased with increased age, mid brain AP diameter shows reduction until the age of 61yrs and after 60 years value increased, DIPFA and DCPA ratio (distance from cerebellar peduncles to aqueduct) measurements increased until age 60yrs and decreased at age 61. In males no enough changes in all measurements, the highest value of PAP (pons anteroposterior diameter) seen at age 31-40 and the lowest value after the age of 61. The final conclusion is that the examination of the midbrain, pons, and medulla in neurological disorders and the aging process is required in view of the age and sex-associated normal dimension changes of the brain stem. (6)

3.12 C. Jandeaux et al. conducted study on The study examines the biometry of the cerebellar vermis and brain stem in children using MR imaging reference data from 718 children at a 2019 center. Hospital University France in the journal American Journal of Neuroradiology with impact factor 3.5 which is web of science indexed. The study uses contained midline sagittal parts Vermian height, vermis anterior-posterior diameter, midbrain-pons junction anterior-posterior diameter, and anterior-posterior midpons diameter were the four 2D data that manually evaluated. The agreement between and within observers was measured 718 childrens were (372 boys and 346 girls). The results show the vermis characteristics revealed a phase of rapid growth in the first year, a time of slow development till year five, and finally a phase of near-plateau. The measurements for the brain stem

demonstrated more gradual development. For every criterion, there existed excellent intra- and interobserver agreement. The final conclusion by using easy, repeatable measurements that are simple to apply in everyday practice, provide reference biometric data for the vermis and the brain stem. It's essential for confirm the use of these 2D measurements in conditions that include variations of the cerebellum. (29)

3.13 Veysel ANTAR et al. conducted the study on Morphometric assessment of the external anatomy of fourth ventricles and dorsal brain stem in fresh cadavers in 2018 at department of neurosurgery, Istanbul, turkey in journal Turk neurosurg which is Pub Med indexed with impact factor 0.972. the study uses external anatomy of fourth ventricle and brain stem dorsal were included on 42 fresh cadavers' measurements were taken according to BMI, the study shows no differences between measurements and BMIs facial colliculus was visualized in 92% but not shown in 7.1% when right and left of stria medullaris were examined one bundle in each right and left was seen in(59.5%, 57.1%) two (31%, 33.3%) three (9.5%, 9.5%). The final conclusion to evaluate any distortion in surgical planning and preoperative imaging investigation. (30)

3.14 Susmita Sing et al. conducted the study In 2018, Magnetic Resonance Imaging was used to measure the anterior diameters of normal brainstem at Gandaki Medical College and Teaching Hospital in Pokhara., Nepal in the journal of Gandaki Medical College, Nepal with impact factor 6.459 which is ResearchGate indexed. The study uses cross sectional with the measurements of sagittal diameter at specific levels, such as the distance between the pons' upper border and the midpoint of its superior and inferior colliculi , the pons' anterior surface and the fourth ventricle's floor , just the medulla's anterior-posterior diameter measured in relation to its long axis twist at the cervicomedullary junction for the medulla oblongata on 103 patients (51 male and 52 females) of age group 8 to 81 yrs. on T1 sagittal images. The results show Mesencephalic diameter significantly correlated with age. There was no positive connection, Pons to medulla ratio and midbrain to pons ratio both showed a strong positive connection with aging, Pontine and medullary diameters did not significantly correlate with age the results of the research showed that there were no significant variations in the anteroposterior diameters of the mesencephalon, pons, and medulla oblongata between males and females. The final conclusion the sagittal diameter of the midbrain, pons, and medulla did not have a statistically meaningful relationship with the patient's gender, at age 20, the brainstem's sagittal diameter reached its highest point and ended growing. After age

50, the sagittal diameter of medulla and midbrain dropped marginally, and after age 70, it fell significantly. The sagittal diameter of the pons did not diminish with age. (31)

3.15 Rebecca A Lundwall et al. conducted the study on The study investigates the correlation between brain stem volume and aggression in children diagnosed with autism spectrum disorder in 2018. at University of Wisconsin-Madison, Madison USA in journal of HHS public access with impact factor 39.207 which is PubMed indexed. The study uses aggressive behaviours disorder we started with information on the brain volume of the brainstem, amygdala, orbitofrontal cortex, anterior cingulate cortex, and dorsolateral prefrontal cortex, which were taken from earlier research on aggression on 3D MPRAGE T1WI sagittal we clarified using the irritability subscale of the aberrant behaviour checklist and lassoing, determine the level of aggression. To choose among these predictor factors using logistic regression. The result shows that the chance of belonging to the high aggression group is higher in p eople with lower brainstem volumes. The final conclusion future studies should examine the structure and operation of the brainstem in ASD to find potential factors behind arising and aggressive behaviour. (32)

3.16 Tomas R.Chivers et al. conducted the study The 2015 American Society of Neuroimaging journal published a study on MRI-based measurement of brain stem cross-sectional area in relapsing-remitting multiple sclerosis at Queen's Medical Centre, Nottingham, UK.. The study uses to find out whether RRMS patients' brain stem cross-sectional areas (CSA) are less than those of age- and sex-matched control subjects ,35 patients with RRMS (14 male 21 females with the age group of 32-44) 35 healthy subjects (14 males 21 females with age group of 29-42yrs) A T2-weighted image with 3 mm transverse continuous pictures and 3 D (MPRAGE) images with 128 continuous slices that extend the entire brain and brain stem were obtained. Three locations the midbrain, the pons, and the medulla oblongata were used to quantify the brain stem's CSA. The result shows the CSA values were much lower in the midbrain, pons, and medulla oblongata. The midbrain had a 9.3% CSA reduction, the pons had an 8.7% reduction, and the medulla oblongata had a 6.5% reduction. The final conclusion an enormously reduced normalized brain stem when RRMS patients were compared to controls who were the same age and gender, CSA was seen in all regions of the brain stem of the RRMS patients. Lack of high cervical cord atrophy in identical patients shows that the pathology in these areas may be independent in some cases. (33)

3.17 Abdelhady T. Emam et al. conducted the study on Progressive Supranuclear Palsy: Brainstem Measurement and its Clinical Implication in 2010 at Department of radiodiagnosis ,Cairo University ,Egypt in the journal of Egypt J Neurol Psychiatry Neurosurg with impact factor 1.22 which is ResearchGate indexed . The study investigates the effectiveness of mid-sagittal MRI measurements in treating progressive supranuclear palsy (PSP) and distinguishing it from Parkinson's Disease and Multiple-System Atrophy of Parkinson Type (MSA-P). and to assess the degree to which these radiological measurements correlate between the clinical features of PSP, On a mid-sagittal MRI, the tegmentum and pons regions of the brain were assessed. In addition to a comprehensive clinical evaluation, patients underwent assessments using the The Hoehn and Yahr Scale, the Unified Parkinson's Disease Rating Scale (UPDRS), and the Mini-Mental State Examination (MMSE) are all used to assess Parkinson's disease. basic neurological evaluations and common laboratory tests on 11 patients PSP and 25 with PD and 8 with MSAP and 20 age of normal healthy subjects.The results shows in comparison to PD patients, MSA-P patients, and the age-matched control group, PSP patients' mean midbrain area and the ratio of midbrain to pontine area were both significantly lower. The radiological parameters investigated in PSP patients substantially Mid-sagittal MRI measurements of the midbrain region are useful diagnostic criteria for distinguishing progressive supranuclear palsy from other common extrapyramidal illnesses and normal aging. (34)

3.18 Nam Joon lee at el. conducted the study on No volume difference of medulla oblangta between young and old Korean people at Korea university college of medicine ,Republic of Korea in 2009 in the journal Elsevier which is PubMed index with impact factor 7.0 .Utilizing magnetic resonance imaging (MRI), investigate The study examines the impact of aging and gender on the brain, brainstem, cerebellum, and lateral ventricles of healthy Koreans. on 115 healthy Korean(28 men and 29 female age range ,20-28 yrs. and 32 men and 26 females of age 62-74 yrs The study utilizes MRI T1 3D MRI volumes to analyze brain structures including brainstem, midbrain, pons, medulla, cerebellum, and lateral ventricle, focusing on age and gender..The result shows effect on age Total brain volume, midbrain volume, and the cerebellum were all much smaller in the older age group than in the younger age group. However, compared to the young-age group, the lateral ventricle was noticeably larger in the older age group. Brainstem, Pons, and Medulla volumetric studies found little variation between the old-age group and the young-age group. Effect on gender Male individuals had much larger Medulla and total

brain volumes than female subjects. However ,there was not much of a difference between men and women in the brain stem, mid brain, pons, cerebellum, or lateral ventricles. Effect of age by gender There is an important gender by age relationship for both Pons and total brain volume. On the other hand, there was no obvious age by gender interaction in the brain stem, mid brain, medulla, cerebellum, or lateral ventricles. The final conclusion there was no difference between the old-age group and the young-age group in the brainstem and medulla, compared to women, men have a higher medulla volume, Men had much bigger variations in pons and total brain volume with age compared to women. (35)

3.19 Makoto Sohmiya et al. conducted the study on An MR image study at a Department of Neurology reveals age-related structural changes in the human midbrain., Gunma University School of Medicine, Japan in 2001 in the journal of Neurobiology of ageing with impact factor 5.133 which is PubMed indexed. The study uses measurements of midbrain on 194 subjects (70 males 24 females) on the parameters of 2D fast spin echo T2 weighted images. The final conclusion the maximal anteroposterior distance of the midbrain through the substantia nigra (MD) was adversely linked with age, the average distance (SNRND) between the substantia nigra and the red nucleus when a link between aging and the maximal distance of the substantia nigra (SND) was discovered. MD, SND, SNRND, and the region of the red nucleus (RNA), which may be in charge of brain hemisphere dominance or handedness, all showed significant left-right differences. In MD, there were discrepancies in the maximum interpeduncular distance (IPD) in groups of similar ages. Midbrain structural alterations brought on by aging may be closely associated to a decrease deterioration of motor skills with age. These findings offer crucial data for analysing MR pictures of neurodegenerative diseases. (36)

3.20 H.Oguro et al. conducted the study on the *Sex differences in morphology of the brain stem and cerebellum with normal ageing* in normal patients in 1998 at journal neuro radiology with impact factor 0.437. Morphometry changes in brain stem and cerebellum structure according to age over 40, 152 patients 81 males and 71 females , this study use diameter of each section of brain stem was measured and the ratio of each diameter to the space between the internal occipital protuberance and the posterior clinoid process was computed and the ratios of the pons base and the vermis of cerebellum to the size of cranium. The result shows in men midbrain tegmentum (MT), mid brain pretectum (MP) and the base of the pons (PB) all revealed considerable age-

related shrinkage, no alteration to fourth ventricle or pontine tegmentum , MT and MP dramatically decreased after the age of 60 on the other hand ,the PB started to shrink after the age of 70. In females only MP had a noticeable aging impact, which didn't start until beyond age 50 and was more consistent. Area of measurements in male shows after 70 age related changes like shrinkage of cerebellar vermis, no change in the area of pons and PA or CA(cerebellar vermis) in women. Age related supratentorial atrophy both in male and females.(37)

3.21.Jyotindu Debnath et al. (2022) conducted a study on "Normal measurements of brainstem and related structures for all ages: An MRI-based morphometric study" at their Institutional Radiodiagnosis Department and published in Medical Journal Armed Forces India, which is Scopus, Web of Science and UGC indexed journal with an impact factor of 1.07 in 2023. The aim of their study was to assess the linear dimensions and angles of brain stem and other related structures by using MRI modality, which tends to lay down their normative values. The minimum sample size of their study was 128, however they used 1015 subjects as sample size. All the measurements were done on axial brain image of MRI and analysis were done by using SPSS software version 23.0. They found the differences in all variables among different age groups and significantly higher values in males. They concluded that most of the parameters showed an initial increase corresponding to normal growth till the third decade, followed by a gradual decline in values, pons anteroposterior thickness and medulla anteroposterior found to be constant through the third to seventh decade.

3.22.Abdalrahim Y. Mohamed et.al (2023) conducted a study on the "Stereological Measurement of the volume of Medulla Oblongata in Young Adults from MRI using Images" Software in the Journal of International Journal of Biomedicine having an impact factor of 0.51 at the radiology department of Doctor's Hospital Riyadh, Saudi Arabia. They were conducted on 36 patients (18 males and 18 females) who were undergoing MRI brain scans. They used T1 weighted sequence and MP-RAGE for measuring the volume of medulla oblongata based on sex, age, and BMI. They decided on an outcome after researching the important difference between genders in MO volume which was greater in men than in women, and there was no significant connection seen between BMI and MO volume.

3.23.Giammarco milella et.al.(2022) conducted a study on “Medulla oblongata volume as a promising predictor of survival in amyotrophic lateral sclerosis in the Journal of Neuroimaging”: clinical having an impact factor of 4.891 at the Neurology Unit, Department of Basic Medical Sciences, neuroscience, and sense organs, university of bari “Aldo Moro”, Italy. The purpose of this study was to look into the lead of brainstem structures as accurate biomarkers of disease severity and predictors of survival. A total of 60 ALS patients and 30 healthy control subjects (CS) were recruited in this investigation. Patients were split up into two categories. Subgroups are based on the initial stages of the disease: 42 spinal (S-ALS) and 18 bulbar (B-ALS). All subjects underwent 3D-structural MRIs. Brainstem volumes both of the entire cohort of ALS patients and S-ALS and B-ALS starting points were contrasted with those of CS. Furthermore, two ALS Brainstem volume differences were investigated between categories. They concluded that d major brainstem atrophy in ALS patients compared to healthy controls was primarily driven by the reduced volume of pons and medulla oblongata. Furthermore, B-ALS patients showed a smaller medulla oblongata volume compared to S-ALS patients.

3.24.Amrutha Ranganath et al. (2022) conducted a study on age and gender differences in morphometric measurements of brain stem using Magnetic Resonance Imaging in Healthy Indian Adults in at Sri Devaraj Urs Medical College and University, Karnataka and published in Journal of Datta Meghe Institute of Medical Sciences University, which is Scopus indexed with an impact factor of 0.11 in 2023-24. The sample size of the study was 142 who were above 18 years of age. Linear measurements of the brain stem were taken from T1 sagittal MRI images and organized in a Microsoft Excel sheet, followed by SPSS software for analysis. They resulted that no significant association between gender and the morphometric measurements of the brain stem. This suggests that the observed changes in brain stem dimensions are primarily influenced by age rather than gender. The mean diameters of the brain stem in both males and females were found to be 1.67 ± 0.17 cm at midbrain, 2.16 ± 0.18 cm at pons, 1.39 ± 0.16 cm and 1.08 ± 0.13 cm for medulla oblongata at the pontomedullary and cervicomedullary junction, respectively. The study concluded that there is a statistically significant reduction in the anteroposterior (AP) diameters of brain stem structures with advancing age.

3.25.Öksüzle et .al (2022) Conduct study on “Evaluation of the Brain Indexes of Subjects with and without Brain Atrophy Using Computed Tomography”. Department of radiology. The study was published in journal of the Anatomical Society of India in 2022. Which is google scholar indexed. Data was 520 senior subjects (196 subjects having brain atrophy and 324 subjects having no brain atrophy) aged 60–90 years. The study based Measurements of the brain indexes were taken from subjects having axial brain CT image. Furthermore, the data were analyzed according to age and gender. The result shows mean brain index values are shown an increase due to age, (except SI values). The SI values are shown to decrease due to age according to gender, in all data means (except SI), it is seen that male's values are greater than females'. Finally, the mean values of all measurements are found higher in subjects with brain atrophy than healthy elderly group.

3.26.Li-Hsin Tai et.al (2021) conducted a study on MO germinoma with Klinefelter Syndrome in the British Journal of Neurosurgery having an impact factor of 1.124 at the Kaohsiung, Taiwan, Kaohsiung Medical University Department of Neurosurgery. This is an instance of a case study of a 25-year-old man who demonstrated signs of persistent syncopal episodes from two years earlier Because of autonomic dysfunction, neurocardiogenic syncope was first diagnosed in him. other relevant indications are hand numbness, headache, and fatigue. after the procedure, four months later, the whole tumor had been removed, according to brain MRI imaging scans, and there had been no further growth. In conclusion, they contend that there is a causal relationship between MO For individuals with intracranial germinomas and chromosomal instability, regular karyotyping is essential.

3.27.Hajer Alriah et.at (2021) Conduct the study on “Morphometric Assessment of Cerebellum in Sudanese Population Using MRI”. Department of College of Medical Radiological Sciences, Sudan University of Science and Technology, Khartoum, Sudan. The study was published in journal Crescent Journal of Medical and Biological Sciences in 2021. Impact factor Which is google scholor indexed . Data was 100 normal individuals with an age range of 3 months to 80 years old (males: 42%) were evaluated. The study based for the gender and age on cerebellum is significant for pathophysiological studies of degenerative brain disorders. The result shows mean of the right hemisphere width, right hemisphere length, left hemisphere

width, left hemisphere length, maximum hemisphere width, maximum hemisphere length, anteroposterior width, and anteroposterior length was 4.38, 4.88, 4.46, 4.42, 9.73, 6.42, 4.88, and 3.54, respectively, implying that the measurement variability was important.

3.29.Polat et al. (2020) performed a study on “The morphometric measurement of the brain stem in Turkish healthy subjects according to age and sex” at Turkey and published in Folia Morphologica Journal, which is Scopus indexed with an impact factor of 1.17 in 2023. The aim of their study was to evaluate the age and sex differences of brainstem and their related structures in Turkish population by using MRI. They took sample size of 263 healthy adult subjects including 158 females and 105 males of between 18–65 years of age. All the parameters of brain stem were measured in T2 weighted image and analysed by using SPSS software. They resulted that males exhibited higher mean values in most brain stem measurements compared to females, particularly in certain morphometric measurements, such as the vertical diameter of the pons and mesencephalon. In females, age related changes were noticed in DIPFA values (interpeduncular fissure and aqueduct distance) as it decreases with age, with the lowest values recorded in the seventh decade of life. For males, no statistically significant differences were found across all measurements. In conclusion, this study established the normative data that can serve as a reference for future research and clinical evaluations. The findings indicate that there are significant age-related changes in the dimensions of the brainstem, particularly after the age of 50. Furthermore, the study highlights that, exhibit significant differences between sexes, with males generally showing larger dimensions than females.

3.30.Masashi Suzuki et al. (2020) conducted a study entitled “Relationship between cardiac parasympathetic dysfunction and the anteroposterior diameter of the medulla oblongata in multiple system atrophy” at Nagoya University Hospital and published in Clinical Autonomic Research Journal, which is Scopus indexed with an impact factor of 2.21 in 2022-23. The main aim of their study was to assess the relationship between cardiac parasympathetic dysfunction and the anteroposterior diameter of the Medulla Oblongata in MSA. They used 40 patients as a sample size and measured the diameters of the midbrain, medulla oblongata and pons by conventional MRI. They found out that no significant differences in age or sex

between the controls and patients with MSA. The significant differences were observed in cardiac autonomic function and brainstem diameters. The decrease in brainstem diameters, pons diameter and MO diameter- were found in the patients with MSA. In summary, they identified a relationship between anteroposterior diameters of the MO and cardiac autonomic parameters, especially in patients with MSA. In conclusion, the anteroposterior MO diameter correlated with the degree of parasympathetic dysfunction in MSA patients, thus the measurement of the MO diameter by conventional MRI is useful for evaluating autonomic failure in MSA during the early phase. Therefore, MRI is a potential imaging marker of parasympathetic dysfunction.

3.31.Laura Sander et.al (2020) Conduct a study Improving accuracy of Brainstem MRI Volumetry Effect of Brain of Age and sex, and Normalization Strategies" Neurologic Clinic and Policlinic, Departments of Medicine and Clinical Research, University Hospital Basel and University of Basel, Basel, Switzerland. The study published in journal Frontiers in Neuroscience. Which google scholor indexed. Data was e extrinsic variability of brainstem volume assessments across scanners and protocols was investigated in two groups comprising 11 (median age 33.3 years, 7 women) and 22 healthy subjects (median age 27.6 years, 50% scanned twice and compared using Dice scores. Intrinsic anatomical inter-individual variability and age and sex effects on brainstem volumes were assessed in segmentations of 110 healthy subjects (median age 30.9 years, range 18–72 years, 53.6% women) acquired on 1.5T (45%) and 3T (55%) scanners. Aim of this study e aimed to develop efficient normalization strategies to reduce the effects of intrinsic anatomic variability on brainstem volumetry. The result shows extrinsic variability of brainstem volumetry across different field strengths and imaging protocols was low (Dice scores > 0.94). Mean inter-individual variability/SD of total brainstem volumes was 9.8%/7.36.

3.32. Sushma Singh et al. (2019) performed a study on "Measurement of Anteroposterior diameters of normal brainstem by Magnetic Resonance Imaging" at Gandaki Medical College, Kaski and published in Journal of Gandaki Medical College-Nepal, which is Google Scholar indexed. They used 103 MRI brain scans as a sample size and measurments were done on T1 weighted images. T-test were done to analyse the corelation between gender and age by using SPSS Software

and Microsoft Excel. They found out the positive corelation of mesencephalic diameter, pons to midbrain ratio and pons to medulla ratio with age. No significant differences of anteroposterior diameter of mesencephalon, anteroposterior diameter of pons and anteroposterior diameter of medulla oblongata between males and females. No statistically significant correlation was found in the sagittal diameter of midbrain, medulla and pons with gender. They concluded that diameter of midbrain declines with respect to age, wherease pons and medulla found to have significant changes with respect to age.

3.33.Veysel Antar et al. (2019) conducted a study on “Morphometric Assessment of the External Anatomy of Fourth Ventricle and Dorsal Brainstem in Fresh Cadavers” at Istanbul Training and Research Hospital, Turkey and published in Turkish Neurosurgery Journal which is PubMed indexed with an impact factor of 0.9 in 2024. The aim of the study was to provide a morphometrical data which may be necessary during surgery. They took 42 samples of cadaver including 26 males and 16 females, as a sample size for their study. They resulted that no statistically significant difference was found between measured parameters and BMIs. There were no correlations between the brain structure features and the ages. No significant differences were observed between the brain structures and the gender ($p>0.05$). They concluded that the morphometric measurements of brainstem did not alter according to the age, gender, and BMI in Turkish population.

3.34.Jandeaux et al. (2019) performed a study on “Biometry of the Cerebellar Vermis and Brain Stem in Children: MR Imaging Reference Data from Measurements in 718 Children” and published their study in American Journal of Neuroradiology, which is Scopus indexed with an impact factor of 2.76 in 2023-24. The main aim of the study was to provide the biometric reference value for brain stem and cerebellar vermis The sample size of their study was 718 including age group from infants to 15 years of age. The values of all the parameters were higher in boys except for APD-MP, which were similar in both genders. Vermis parameters proved to be in very rapid growth phase during the first year, then a slower growth until the fourth year. The brain stem parameters showed more progressive growth, with relatively rapid growth during the first four years and then slower thereafter. The values of these parameters were higher in boys as compared to opposite gender.

3.35.Beatrice Paradiso1,2 et al. (2018) Conduct the study on “Variability of the medullary arcuate nucleus in humans”. Department of Biomedical, Surgical and Dental Sciences, University of Milan, Milan, Italy. The study was published in Journal Wileyonlinlibrary.com/Journal/brb3 in 2018.The morphometric In-depth analyses of their brainstems analysis allowed to obtain valid and objective quantitative results in support of the microscopic diagnoses. Data was 25 adult subjects, 18 males and 7 females, aged between 34 and 89 years. The result of this study For almost half of the cases (44%) microscopic examinations of serial histological sections of medulla oblongata showed a normal cytoarchitecture of the arcuate nucleus, extending along the pyramids. For the remaining 56% of cases, various degrees of hypodevelopment of this nucleus were observed, validated through the application of quantitative morphometric investigations, from decreased area, neuron number and volume, to full aplasia.

3.36.SvenF.Garbade1 et al.(2018) Conduct the study on “Age-Related Changes and Reference Values of Bicaudate Ratio and Sagittal Brainstem Diameters on MRI”. Department of Neuroradiology, University Hospital Heidelberg, Heidelberg, Germany. The study was published in journal Neuropediatrics in 2018. Which is google scholar indexed. Data was 920 patients (500 female, 420 male). The study based for bicaudateratioasa measure of global supratentorial volume, aswell as the maximal anteroposterior diameters of mesencephalon, pons, and medulla oblongata as parameters of brainstem volume. The result shows Maximal sagittal brainstem diameters rapidly increased during the first decade, which, in pons and medulla oblongata, was followed by a plateau and a subsequent slow decrease beyond the sixth decade. In the mesencephalon, the plateau phase was shorter, with a slow decrease begin ning after the fourth decade. Polynomial regression revealed significant sex-related differences in BCR, pons, mesencephalon, and medulla oblongata.

3.37.Iuliia Zhuravlova et.al (2018) Conduct the study on “Anatomic Variability of the Morphometric Parameters of the Fourth Ventricle of the Brain”. Department of Anatomy,Trinity School of Medicine, Kingstown, St. Vincent and the Grenadines. The study was published in journal JNeurol SurgB 2018.Which is google scholor indexed. Data was 118 normal computed tomography scans of the head of people aged from 21 to 86 years (meanage—48.6years 17.57)were selected for the study. The study

based on the identify the correlation between the morphometric parameters of the fourth ven tricle of the brain and the shape of the skull in middle aged people. The result shows the presence of a statisticallysignificantdifference between morphometric parameters of the fourth ventricle of the brain in dolichocranial, mesocranial ,and brachycranial individuals.

3.38.Zahra Heidari et al. (2017) Conduct the study on" Stereological Evaluation of the Brains in Patients with Parkinson's disease Compared to Controls" from MRI . Infectious Diseases and Tropical Medicine Research Center, Zahedan University of Medical Sciences, Zahedan, Iran in 2017. Which is google scholar indexed. The study based on clinical diagnosis of Parkinsos diseases 29 patients with Parkin son's disease w ere compared to 12 healthy individuals without any history of neurological or psychiatric disorders. Cavalieri's point counting method was employ to estimate the volume of the brain and its components using the formula on FLAIR (Fluid Attenuated Inversion Recovery) MR images. The result show that total ventricular volumes and volume density of lateral ventricles were not statistically significant between Parkinson disease and control groups.

3.39.Alessandro Finkelsztejn et al. (2017) Conduct the study on "Intercontinental validation of brain volume measurements using MSmetrix" from MRI. Department of Neurology, Hospital de Clinicas de Porto Alegre, Brazil in 2017. Which is google scholor indexed. The study measure Whole brain volume and grey matter volume from each of these subjects were plotted against the standard, normal values already included in the MSmetrix population graphs. Data was 295 individual 92 men and 203 women, with a median age of 35 years (range: 5–78 years).The results With regard to whole brain volume, only 2% of the healthy adult subjects from Brazil were below the 5th percentile of the graph, and for grey matter volume, only 3% of the subjects were below the 5th percentile of MSmetrix standards.

3.40.Alessandro Finkelsztejn et.al (2017) Conduct study on "Intercontinental validation of brain volume measurements using MS metrix" MRI. Department of Department of Neurology, Hospital de Clinicas de Porto Alegre, Brazil. The study published in journal The Neuroradiology Journal 0(00) 1–3 in 2017. Impact factor Which google scholar indexed. Data was 295 individual 92 men and 203 women, with a median age of 35 years (range: 5–78 years). The result shows With regard to

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3.41.Nagwan Elhussein et al. (2017) conducted a study on “Norms for Brain Stem: A morphometric MRI Based Study” at Radiology Department of Alhada Military hospital and King Faisal Hospital, Taif City. They published their article in Journal of Dental and Medical Sciences, which is PubMed indexed with an impact factor of 5.1 in 2022. The sample size of their study was 275 including 126 females and 149 males. They resulted that there was showed significant reduction of the brain stem measurement with increasing age at medulla oblongata, mid brain and pons. The age-related degeneration was seen in the midbrain. No measurement loss in pons and medulla found out with aging. There was no significant relationship between the brain stem measurements and gender. The study showed that the mid brain declines in the measurements by 3mm in saggital plane at the age more than 50 years and by 13mm as the age surpassed 60years. The pons was found to be increased in size significantly at age >50 years and decline by 0.03 at the age above 60 years. They concluded he normative values for different age groups to assess the changes in suspected neurodegenerative disorders cases.

3.42.Sven Garbade et al. (2017) conducted a study on “Age-Related Changes and Reference Values of Bicaudate Ratio and Sagittal Brainstem Diameters on MRI” at University of Heidelberg and published in Neuropediatric Journal, which is Scopus indexed with an impact factor of 1.4 in 2022. The aim of their study was to evaluate the normative value and age-related parameters of brainstem volume. They patients as a sample size, including 500 females and 420 males. They found out that the intercaudate distance decreased during infancy and childhood, reaching a minimum during the second half of the first decade. BCR correspondingly decreased in infancy and more slowly in early childhood. Values subsequently increased during the second decade and more slowly during adulthood, with a mean BCR of 0.1329 at 80 years. Maximal sagittal brainstem diameters rapidly increased during the first decade, which, in pons and medulla oblongata, was followed by a plateau and a subsequent slow decrease beyond the sixth decade. The significant sex-related differences found in BCR, pons, mesencephalon, and medulla oblongata. The difference between males and females was 0.003 for BCR, 0.75 mm for pons, 0.22

mm for mesencephalon, and 0.3 mm for medulla oblongata. These effect sizes indicate that sex-related differences possess only 1% to 7% of variance in the sample.

3.43.Saurabh Jain et al. (2015) Conduct the study on “Automatic segmentation and volumetry of multiple sclerosis brain lesions from MR images” from MRI .Department of Neurology, Center for Neurosciences, Universitair Ziekenhuis Brussel.The study was published in NeuroImage:Clinical in 2015. Which is google indexed. Data was 20 MS patients participated in a study at VU University Medical Center, Amsterdam, the Netherlands. 10 MS patients participated in a study at UZ Brussels, Brussels, Belgium. The result shows are compared both quantitatively and qualitatively with two well-known and publicly available automatic unsupervised lesion segmentation software implementations.on when comparing the brain stems of the RRMS patients to age and gender-matched controls.

3.50.Tomos5 R. Chivers et.al.(2015) conducted a study on “MRI-Based measurement of brainstem cross- a sectional area in relapsing-remitting multiple” in the Journal of ASN having an impact factor 3.5 at the Nottingham, United Kingdom-Queen's Medical Centre – university hospital NHS, Department of Clinical Neurology Trust. they performed on 35 RRMS patients (14 men & 21 women) and 35 command patients (14 men and 21 women) were enlisted in the research. The control participants' median age was 34 (29 to 42) years, whereas the patients' median age (interquartile range) was 39 (32 to 44) years. As a result of this investigation, it was determined that normalizing subject variance using the TECV was an effective method. A substantial decrease restored normalcy to the brain stem. CSA was seen in every region.

3.44.Pauline A. et al.(2014) conducted a study on “The young adult human brain: an MRI based morphometric analysis by Magnetic Resonance Imaging” in the Journal of Oxford journals having an impact factor 1.3 in the Department of Pediatric Neurology Harvard Medical School's Massachusetts General Hospital Radiology Department Boston. The goal of this study was to determine whether cortical asymmetries are associated with volumetric asymmetries of cerebral structures. They performed with informed consent 20 subjects (10males, and 10 females).in

which seven males and eight females were strongly right-handed on coronal 3D T1-weighted spoiled gradient echo MRI scans. They evaluate that there were no differences noted between women and men in the symmetry or Pearson coefficients for left and right volumes of the cerebrum, cerebellum, or component sub-structures. The size of the brain in men is bigger than in women a variation that became significant for cerebellar not for cerebral hemisphere volume.

25.Jin Mo Cho et al.(2010) conducted a study on An endodermal cyst mimicking an intra-axial tumor in the MO in the Journals of Child Nervous System having an impact factor of 1.532 at the Yonsei University College of Medicine's Department of Neurosurgery Brain Research Institute, Korea. They give an example of a 23-year-old man with an endodermal cyst situated inside the medulla oblongata. He had a past of two months of gradually increasing nausea and dizziness. Clinical and neurological examinations were normal. Magnetic resonance (MR) imaging of the brain demonstrated a cystic mass located inside the MO and with probable extension into the corticomedullary junction. They concluded that total resection of endodermal cysts inside the MO is recommended, despite their location and adhesion to surrounding structures. Subtotal removal results in recurrence within a relatively short period.28

3.47.Nam Joon Lee et.al.(2009) conducted a study on “No volume difference of medulla oblongata between young and old Korean people by Magnetic resonance Imaging” in the Journals of Brain Research having an impact factor of 3.61 in the Department of Radiology of Korea University, Republic of Korea. The study aim was to assess the consequences of aging and gender on the volume of the total brain, brainstem, cerebellum, and lateral ventricle. They conclude that the substantial effect of age on the volume of the midbrain, cerebellum, and lateral ventricle, except for the volume of the medulla. Substantial age differences in the volume of the midbrain, but not of the medulla were especially notable. In addition, men showed a larger volume of medulla than women. Furthermore, men showed greater age-related variation in the volume of total brain and pons than women.

3.48.Dieter Woischneck et al.(2009) conducted a study on the correlation between injury of the brain as visualized in cranial MRI and the ability of spontaneous respiration in the Journals of Neurological Research having an impact factor of 2.592

at the Neurosurgery department, Germany's University Hospital in Ulm. They involved two hundred individuals who suffered from traumatic brain injuries. Among them, 144 were male and 56 were female. The patients' ages ranged from 1 to 86 years, with an average age of 35 years. 50 patients were involved with ICH patients (14 females & 56 males) who had a mean age of 67 years (ranging from 25-81 years). They have determined that this study confirms the presence of an independent respiratory centre in the caudal MO of humans that allows impulsive respiration in deep coma. Magnetic resonance imaging can be predict cessation of centrally triggered breathing, which is likely observed with bidirectional MO injury.

3.49.Z.Liptak et al.(2008) conducted a study on MO Volume: A Multiple Sclerosis biomarker of spinal cord damage and disability in the Journal of American Journal of Neuroradiology having impact factor 3.653 at Brigham and Women's Hospital's Department of Neurological Imaging, Harvard Medical School Boston. The research aimed to evaluate if measurements of MOV on routine brain MR imaging could serve as a biomarker and disability in MS. In this investigation, 45 MS patients with head and cervical spinal cord MR imaging were identified along with 29 age and gender matched well-controlled individuals who had head MR imaging. They concluded that medulla oblongata volume is a readily accessible metric that displays non-negligible benefits, particularly when it comes to extensive clinical routes in Multiple sclerosis. They have put forth a simple technique for Medulla oblongata volume measuring on normal clinical head magnetic resonance imaging. Initial findings have indicated the application of Medulla oblongata volume perhaps serving as a spinal cord biomarker marker.

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CHAPTER -4

MATERIALS AND METHODOLOGY

4.1 STUDY SITE-

This was performed at the Santosh Hospital and Research Center. Department of Radiodiagnosis in Ghaziabad Uttar Pradesh, India.

4.2 TYPE OF STUDY-

This is a prospective, observational, clinical based consideration in Department of Radiodiagnosis at Santosh Hospital and Research Center in Ghaziabad Uttar Pradesh, India.

4.3 STUDY DESIGN-

This study is designed as a cross sectional-based consideration, to measure the age, sex, and BMI related changes in MRI brain according in the Santosh Hospital and Research Center in Ghaziabad Uttar Pradesh.

4.4 STUDY POPULATION-

The subjects were 157 who came to the hospital's outpatient department (OPD) for general checkups at Santosh Hospital and Research Center Ghaziabad Uttar Pradesh.

4.5 STUDY DURATION- June 2023 to August 2024

4.6 STUDY CRITERIA- This clinically based investigation was conducted from at Santosh Hospital and Research Center in Ghaziabad.

INCLUSION CRITERIA-

- Subjects with no brainstem pathologies.
- Subject of age 20 to 60years

EXCLUSION CRITERIA-

- Patient of age less than 20years
- Early traumatic patients
- Patient related to brain pathologies
- Prior neurosurgical intervention

SAMPLE SIZE- 157 Patient

SAMPLE SIZE CALCULATION

Slovin's Formula

$$n= N/(1+Ne^2)$$

where,

n= Sample size

N= Population

e = Error margin

CONFIDENCE LEVEL-95%, MARGIN OF ERROR 5%, POPULATION PROPORTION 50%, POPULATION SIZE 157

Figure 4.1. United Imaging 1.5 T MRI machine.

MATERIALS AND METHOD-

Our study objective is to measure the AP diameter of mid brain, pons and medulla on MRI including on 157 Indian adults with respect to age, gender and BMI with the age 20 to 60years i.e., categories into four age groups 20-30, 31-40, 41-50, 51-60. This research were take place in the Teerthanker Mahaveer Hospital and Research Centre in the Department of Radiology on the MRI machine 1.5 tesla United imaging With the help of BRAIN MRI examination with inclusion and exclusion criteria we will gather data and information by using linear measurements on T1 sagittal plane.

Measurements are:-

- Mid brain(AP diameter between superior and inferior colliculi),
- Pons (AP diameter between anterior surface of the pons to the floor of the fourth ventricle),
- Medulla (AP diameter perpendicular to the longitudinal axis at pontomedullary junction and cervicomedullary junction).

Statistical analysis:-

The data was analyzed using Descriptive Statistics and the Independent sample "t" test to compare brainstem diameters based on gender. The One way ANOVA was used to compare

brainstem diameters according to age groups and BMI. The Post hoc analysis, Tukey test was used for the multiple comparisons of brainstem diameters: MBAP, PAP, and MPMJ according to age groups. To find the relation between the various parameters of brainstem diameters; the Pearson correlation coefficient ("r") was used. 29. The data was analyzed using SPSS software, with a significance level of $p < 0.05$.

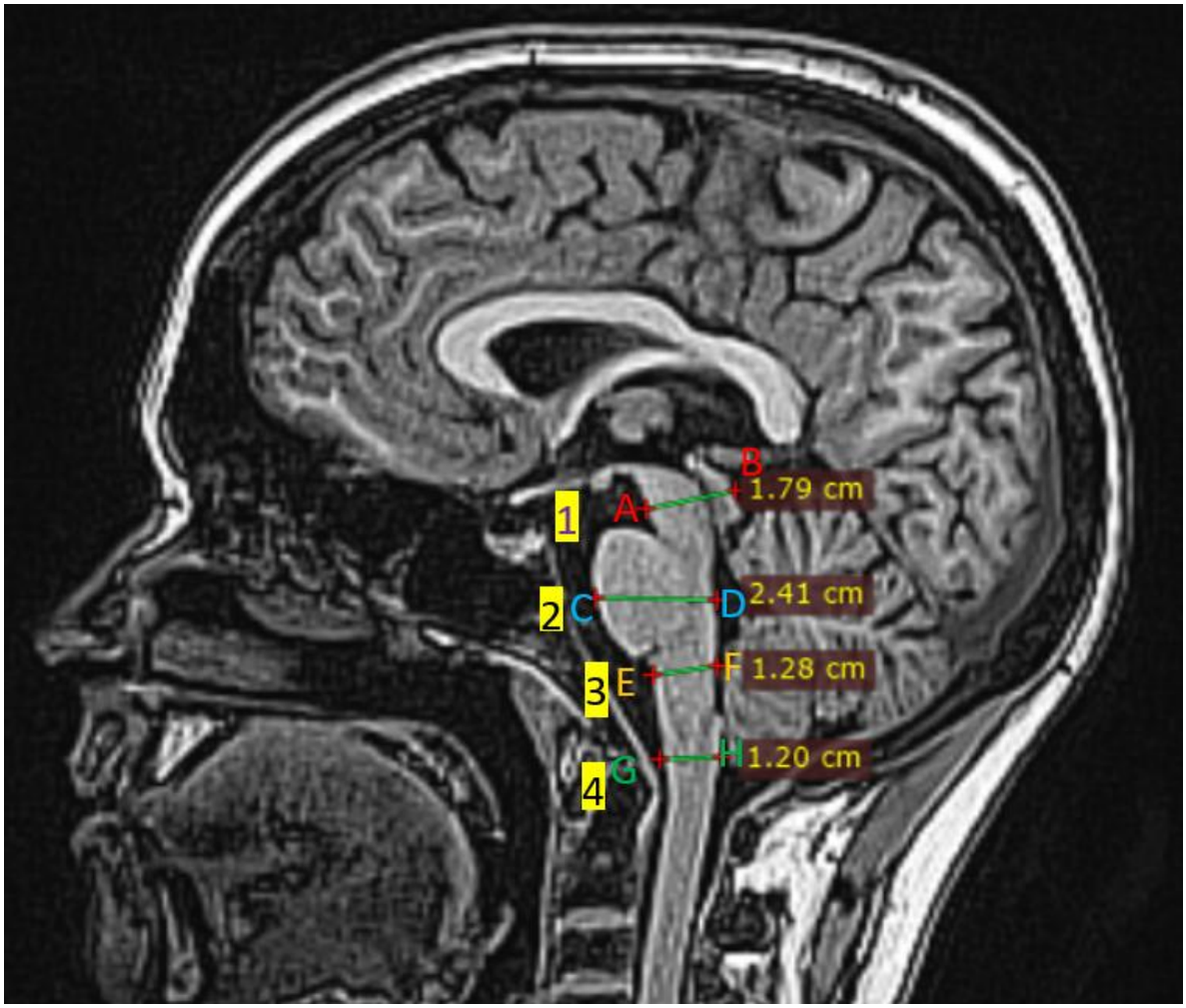


Fig 4.2 :- T1 sagittal neruroshield image demonstrating midsagittal AP diameters of the (1)Midbrain {A} superior colliculi {B} inferior colliculi],(2)Pons {C} anterior surface of the pons {D}floor of the fourth ventricle ,(3) medulla oblangata {E-F}Pontomedullary junction and {G-H}Cervicomedullary junction.

METHOD OF DATA COLLECTION

ROUTIEN MRI

SEQUENCES	TE (ms)	TR (ms)	SLICE THICKNESS (mm)	SLICE INCREMENT(mm)	FOV READ(mm)	FOV PHASE(%)	PHASE ENCODING (Dir)
T1_BLADE_TRA	44	2500	5.0	1.5	230	100.0	R>>L
T2_BLADE_TRA	99	5000	5.0	1.5	230	100.0	R>>L
T1 SAG MPRAGE NEUROSHIELD	2.83	2200.0	1.0	0.5	256	100.0	A>>P
T2_swi3d_tra_p2_2mm	40	49	3.00	0.6	230	81.3	R>>L
T2_BLADE_TRA_FLAIR	99	9000.0	5.0	1.5	230	100.0	R>>L

Table 4.1 Routine MRI BRAIN protocol

CHAPTER -5

RESULTS

Table 5.1: Descriptive Statistics for age, height, weight, BMI and brainstem diameters

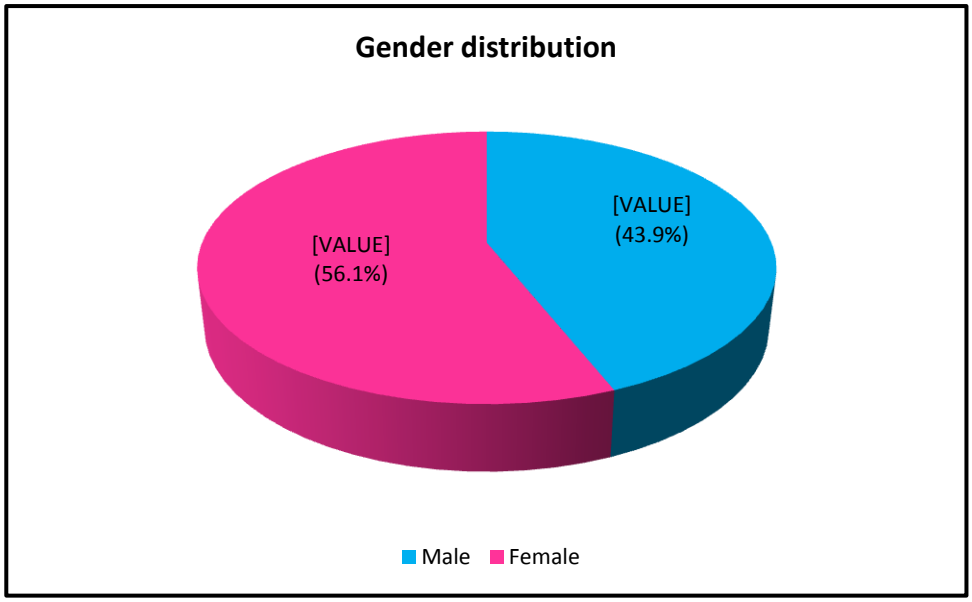
(n = 157)	Range	Mean	S.D.
Age (Years)	20 to 60	37.81	11.87
Height (Cm)	134.1 to 182.8	156.97	8.80
Weight (Kg)	40 to 80	60.89	9.20
BMI (Kg/M^2)	14.43 to 36.15	24.78	3.78
MBAP (Cm)	1.45 to 2.19	1.77	0.12
PAP (Cm)	1.91 to 2.63	2.28	0.15
MPMJ (Cm)	1.11 to 1.62	1.39	0.10
MCMJ (Cm)	0.81 to 1.61	1.07	0.12

The above table 5.1 shows mean and standard deviation of age(years), height(cm), weight(kg),BMI(Kg/M^2), MBAP(cm),PAP(cm),MPMJ(cm),MCMJ(cm).

Table 5.2: Distribution of gender, age and BMI

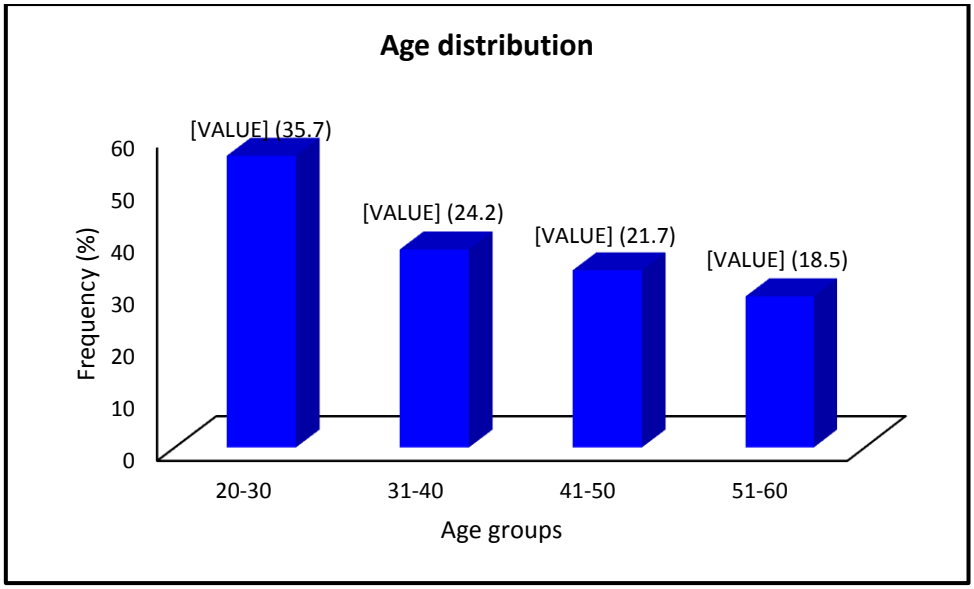
(n = 157)		Frequency	%
Gender	Male	44	43.9
	Female	56	56.1
Age groups	20-30	25	25
	31-40	24	24
	41-50	32	32
	51-60	19	19
BMI	Under weight (< 18.5)	5	4.9
	Normal weight (18.5 to 24.9)	47	47.0
	Heavy weight (25 to 29.9)	34	33.8
	Obese (30 to 39.9)	14	14.0

The above table5.2 shows the frequency of patients to gender, age groups and BMI.In gender female were maximum as 88 with 56.1% , in age groups 20-30 years maxium subjects as shown as 56 with 35.7%, in age groups 31-40 frequency 38 subjects with 24%,in age groups 41-50 frequency 34 subjects with 21.7%, in age groups 51-60 frequency 29 subjects with 18.5%. BMI under weight frequency 5 with 3.2%,healthy weight frequency 77 with 49.0% which were maxium in over all BMI's, over weight frequency 53 with 33.8% and obese frequency 22 with 14.0% respectively.



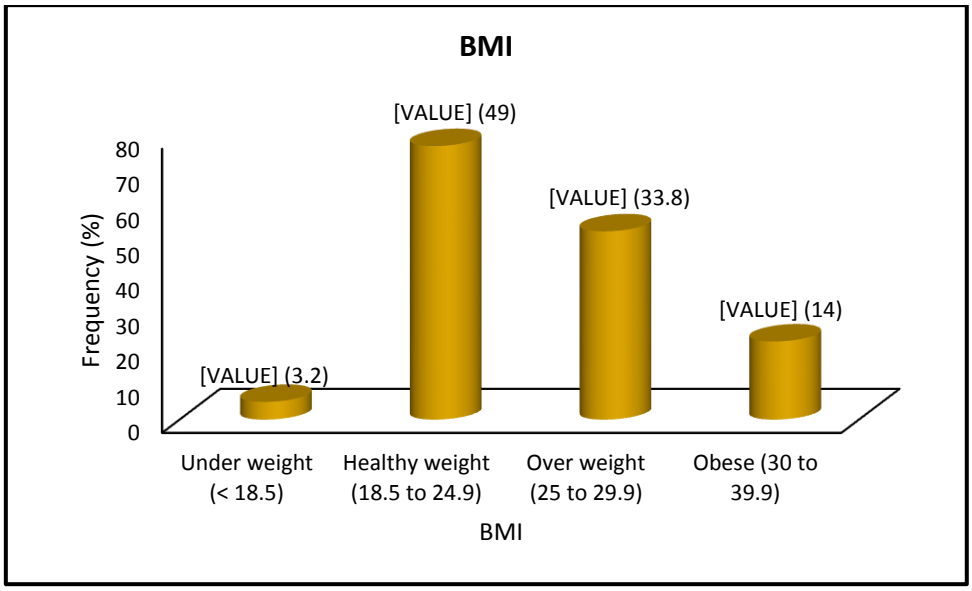
GRAPH:-5.1 Represent the gender distribution

Graph 5.1 shows gender distribution according to gender the male frequency of 88 with 56.1% and in female frequency of 69 with 43.9% respectively.



GRAPH:-5.2 Represent the age distribution

In age groups 20-30 years maxium subjects as shown as 56 with 35.7%, in age groups 31-40 frequency 38 subjects with 24.2%,in age groups 41-50 frequency 34 subjects with 21.7%, in age groups 51-60 frequency 29 subjects with 18.5% respectively.



GRAPH:-5.3 Represent the BMI distribution

BMI under weight frequency 5 with 3.2%,healthy weight frequency 77 with 49.0% which were maxium in over all BMI's, over weight frequency 53 with 33.8% and obese frequency 22 with 14.0% respectively.

Table 5.3: Age and BMI according to gender

		Gender			
		Male		Female	
		n	%	n	%
Age groups	20-30	20	29.0	36	40.9
	31-40	18	26.1	20	22.7
	41-50	14	20.3	20	22.7
	51-60	17	24.6	12	13.6
BMI	Under weight (< 18.5)	2	2.9	3	3.4
	Healthy weight (18.5 to 24.9)	27	39.1	50	56.8
	Over weight (25 to 29.9)	31	44.9	22	25.0
	Obese (30 to 39.9)	9	13.0	13	14.8

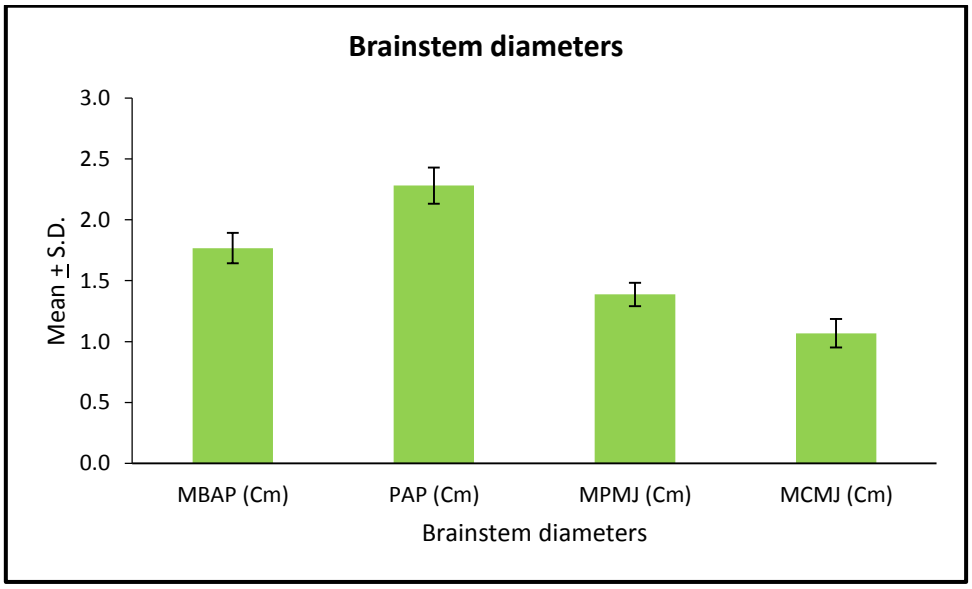
The above table shows age groups between male and female in age groups 20-30 male is 29.0% and female is 40.9 % which is maxium , age group 31-40 male is 26.1% and female is 22.7%, age groups 41-50 male is 20.3% and female is 22.7% and age groups 51-60 male is 24.6% and female 13.6% respectively.BMI between male and female ,male under weight 2.9% and female 3.4%, healthy weight male 39.1% and female 56.8%, male with over weight 44.9% and female 25.0%, male the obese 13.0% and female 14.8%.

Table 5.4: Comparison of brainstem diameters according to gender

	Gender	Mean	S.D.	"t"	p value
MBAP (Cm)	Male	1.76	0.14	-0.77	0.442
	Female	1.77	0.11		
PAP (Cm)	Male	2.30	0.15	1.59	0.113
	Female	2.26	0.15		
MPMJ (Cm)	Male	1.40	0.09	1.50	0.136
	Female	1.38	0.10		
MCMJ (Cm)	Male	1.10	0.11	2.79	0.006*
	Female	1.05	0.12		

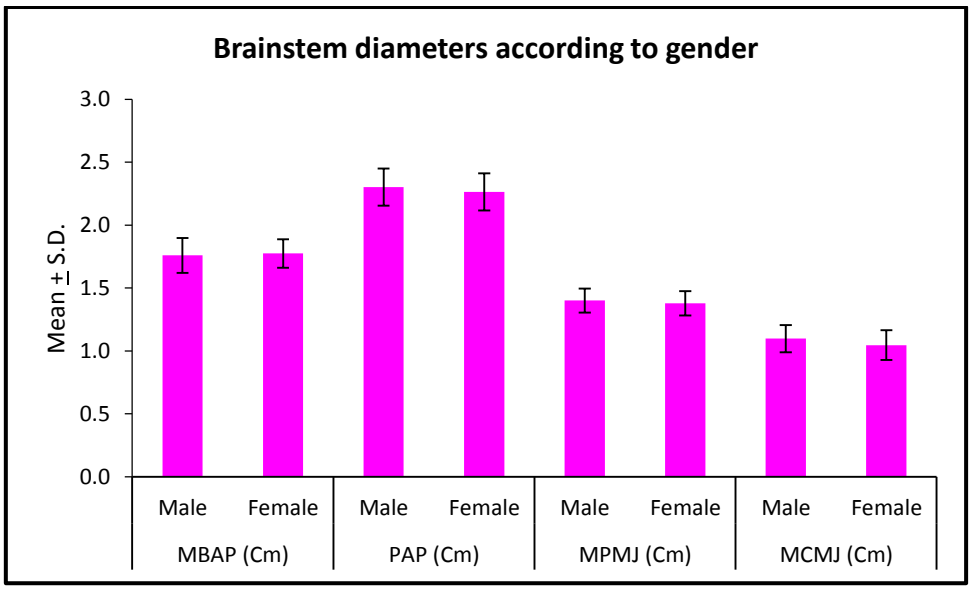
("t" = Independent sample "t" test; * Significant)

The Independent sample "t" test was used to compare the brainstem diameters according to gender. There was a difference ($p < 0.05$) in MCMJ between males and females. [Table – 5.5]



GRAPH:-5.4 Represent the various parameter of brainstem diameter

The above graph 5.7 shows brainstem diameters like MBAP, PAP,MPMJ and MCMJ respectively.



GRAPH:-5.5 Represent brainstem diameter and according to gender

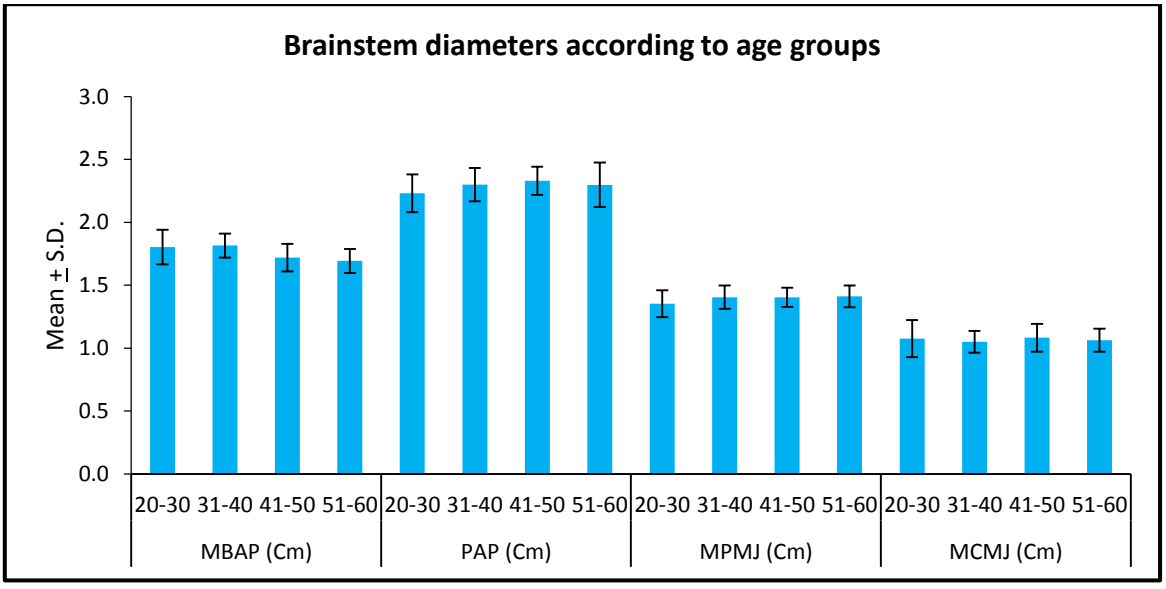
The above graph 5.8 shows comparison of brainstem diameters between male and female with diameters and mean standard deviation**.**

Table 5.5: Comparison of brainstem diameters according to age groups

	Age Groups	Mean	S.D.	"F"	p value
MBAP (Cm)	20-30	1.80	0.14	9.79	< 0.001*
	31-40	1.82	0.10		
	41-50	1.72	0.11		
	51-60	1.69	0.10		
PAP (Cm)	20-30	2.23	0.15	3.99	0.009*
	31-40	2.30	0.13		
	41-50	2.33	0.11		
	51-60	2.30	0.18		
MPMJ (Cm)	20-30	1.35	0.11	3.99	0.009*
	31-40	1.40	0.09		
	41-50	1.40	0.08		
	51-60	1.41	0.09		
MCMJ (Cm)	20-30	1.08	0.15	0.59	0.622
	31-40	1.05	0.09		
	41-50	1.08	0.11		
	51-60	1.06	0.09		

("F" = One way ANOVA; * Significant)

One way ANOVA was used to compare brainstem diameters according to age groups. There was a difference ($p < 0.05$) in MBAP, PAP, and MPMJ according to the age groups. [Table – 5.6]



GRAPH:- 5.6 Represent brainstem diameters according to age groups.

This graph 5.9 shows brainstem diameters within age groups with mean and standard deviation.

Table 5.6: Multiple comparisons of MBAP, PAP, and MPMJ according to age groups

(Multiple comparisons)			Mean Difference	p value
MBAP (Cm)	20-30	31-40	-0.013	0.955
		41-50	0.083	0.007*
		51-60	0.109	< 0.001*
	31-40	41-50	0.095	0.003*
		51-60	0.122	< 0.001*
	41-50	51-60	0.027	0.799
PAP (Cm)	20-30	31-40	-0.070	0.100
		41-50	-0.100	0.009*
		51-60	-0.068	0.173
	31-40	41-50	-0.030	0.818
		51-60	0.002	1
	41-50	51-60	0.032	0.815
MPMJ (Cm)	20-30	31-40	-0.052	0.044*
		41-50	-0.052	0.057
		51-60	-0.058	0.037*
	31-40	41-50	0.000	1
		51-60	-0.006	0.994
	41-50	51-60	-0.006	0.993

(* Significant)

The Post hoc analysis , Tukey test was used for the multiple comparisons of brainstem diameters: MBAP, PAP, and MPMJ according to age groups. The study found a significant difference ($p < 0.05$) in MBAP among the age groups of 20-30 and 41-50 years. 20-30 and 51-60; 31-40 and 41-50; as well as 31-40 and 51-60 years. The PAP exhibited a difference (p

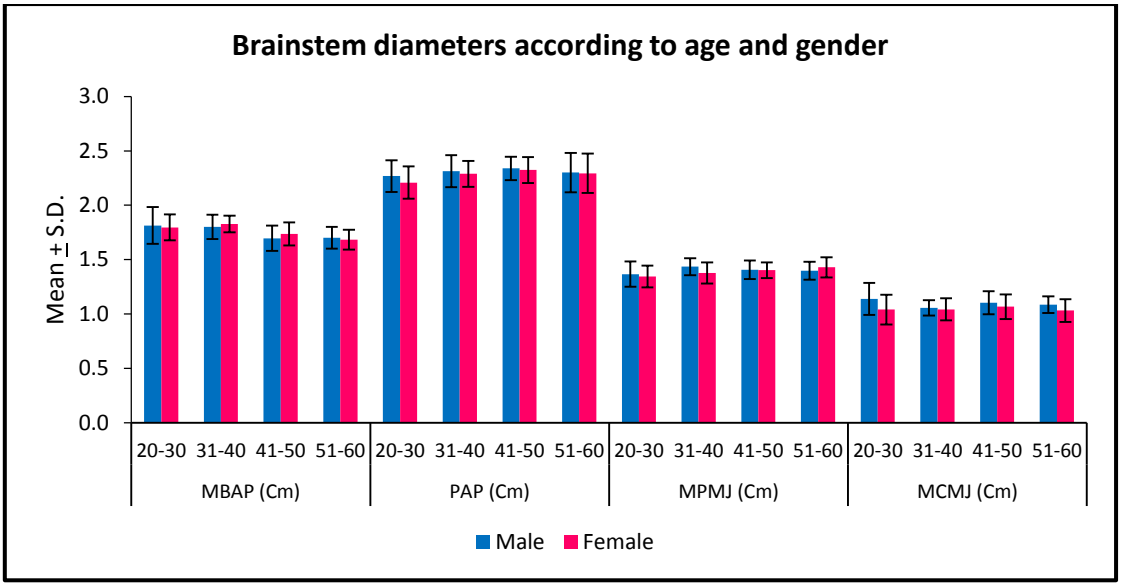
< 0.05) between the age groups 20-30 and 41-50 years. Also, the MPMJ was found to be different between the age groups: 20-30 and 31-40 as well as 20-30 and 51-60. [Table –5. 7]

Table 5.7: Comparison of brainstem diameters between males and females within the age group

	Age groups	Male		Female		"t"	p value
		Mean	S.D.	Mean	S.D.		
MBAP (Cm)	20-30	1.81	0.17	1.80	0.12	0.46	0.645
	31-40	1.80	0.11	1.83	0.08	-0.85	0.404
	41-50	1.70	0.12	1.74	0.11	-1.05	0.302
	51-60	1.70	0.10	1.68	0.09	0.47	0.640
PAP (Cm)	20-30	2.27	0.15	2.21	0.15	1.46	0.150
	31-40	2.31	0.15	2.29	0.12	0.57	0.570
	41-50	2.34	0.11	2.32	0.12	0.37	0.716
	51-60	2.30	0.18	2.29	0.18	0.09	0.926
MPMJ (Cm)	20-30	1.37	0.12	1.35	0.10	0.73	0.472
	31-40	1.44	0.08	1.38	0.10	2.03	0.050*
	41-50	1.41	0.08	1.40	0.07	0.13	0.900
	51-60	1.40	0.08	1.43	0.09	-1.01	0.322
MCMJ (Cm)	20-30	1.14	0.15	1.04	0.14	2.50	0.016*
	31-40	1.06	0.07	1.04	0.10	0.53	0.599
	41-50	1.10	0.11	1.07	0.11	0.96	0.344
	51-60	1.09	0.08	1.03	0.10	1.58	0.125

("t" = Independent sample "t" test; * Significant)

The Independent sample "t" test was used to compare the brainstem diameters according to gender within the age groups. There was a difference ($p < 0.05$) IN MPMJ between males and females within the age group 31-40 years. Also, a difference ($p < 0.05$) in MCMJ was found between males and females within the age group: 20-30 years. [Table –5. 8]



GRAPH:-5.7 Represent the brainstem diameter according to age and gender

The graph 5.10 shows comparison of brainstem daimeters between male and female within the age groups with their mean and standard deviation.

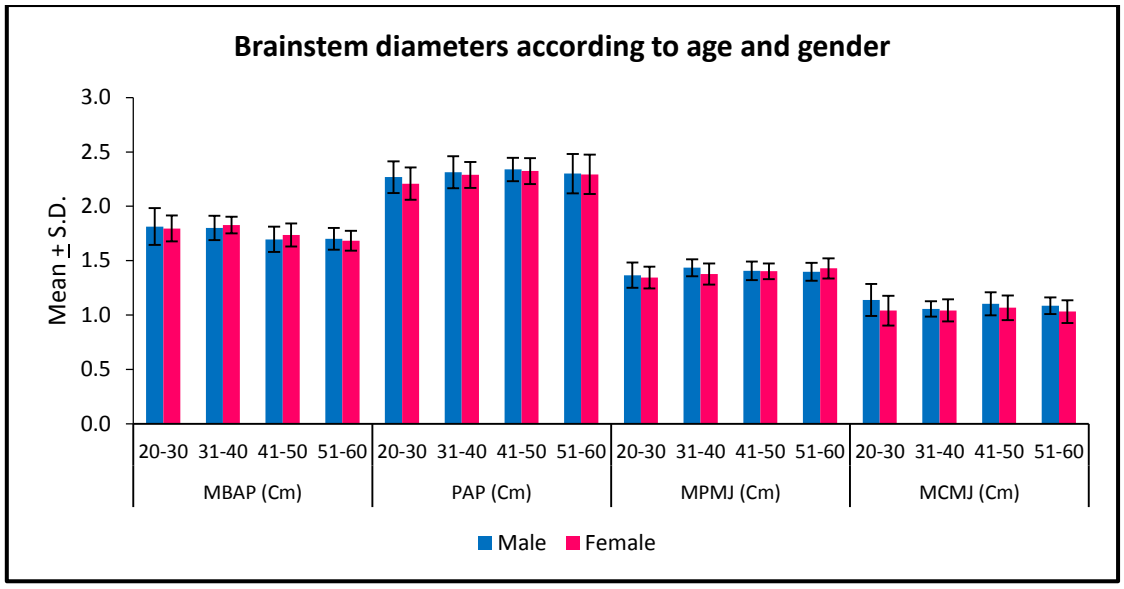
Table 5.8: Comparison of brainstem diameters according to age group within gender

	Age groups	Male				Female			
		Mean	S.D.	"F"	p value	Mean	S.D.	"F"	p value
MBAP (Cm)	20-30	1.81	0.17	4.07	0.010*	1.80	0.12	6.19	0.001*
	31-40	1.80	0.11			1.83	0.08		
	41-50	1.70	0.12			1.74	0.11		
	51-60	1.70	0.10			1.68	0.09		
PAP (Cm)	20-30	2.27	0.15	0.65	0.589	2.21	0.15	3.41	0.021*
	31-40	2.31	0.15			2.29	0.12		
	41-50	2.34	0.11			2.32	0.12		
	51-60	2.30	0.18			2.29	0.18		
MPMJ (Cm)	20-30	1.37	0.12	1.77	0.162	1.35	0.10	3.23	0.026*
	31-40	1.44	0.08			1.38	0.10		
	41-50	1.41	0.08			1.40	0.07		
	51-60	1.40	0.08			1.43	0.09		
MCMJ (Cm)	20-30	1.14	0.15	1.96	0.128	1.04	0.14	0.29	0.834
	31-40	1.06	0.07			1.04	0.10		
	41-50	1.10	0.11			1.07	0.11		

	51-60	1.09	0.08			1.03	0.10		

("t" = One way ANOVA; * Significant)

The One way ANOVA was used to compare brainstem diameters according to age group within gender. There was a difference ($p < 0.05$) in MBAP according to age groups among males. The MBAP, PAP as well as MPMJ exhibited a difference ($p < 0.05$) according to age groups among females. [Table –5. 9]



GRAPH:-5.8 Represent comparison of brainstem diameters according to age and gender

This graph 5.11 shows to compare brainstem diameters according to age group within gender.

Table 5.9: Comparison of brainstem diameters according to BMI

		Mean	S.D.	"F"	p value
MBAP (Cm)	Under weight (< 18.5)	1.83	0.11	1.59	0.194
	Healthy weight (18.5 to 24.9)	1.78	0.11		
	Over weight (25 to 29.9)	1.76	0.15		
	Obese (30 to 39.9)	1.73	0.13		
PAP (Cm)	Under weight (< 18.5)	2.35	0.14	1.21	0.308
	Healthy weight (18.5 to 24.9)	2.26	0.14		
	Over weight (25 to 29.9)	2.29	0.16		
	Obese (30 to 39.9)	2.32	0.15		

MPMJ (Cm)	Under weight (< 18.5)	1.42	0.07	1.70	0.17
	Healthy weight (18.5 to 24.9)	1.37	0.09		
	Over weight (25 to 29.9)	1.41	0.10		
	Obese (30 to 39.9)	1.39	0.08		
MCMJ (Cm)	Under weight (< 18.5)	1.19	0.14	2.65	0.051
	Healthy weight (18.5 to 24.9)	1.08	0.13		
	Over weight (25 to 29.9)	1.05	0.10		
	Obese (30 to 39.9)	1.06	0.11		

("F" = One way ANOVA)

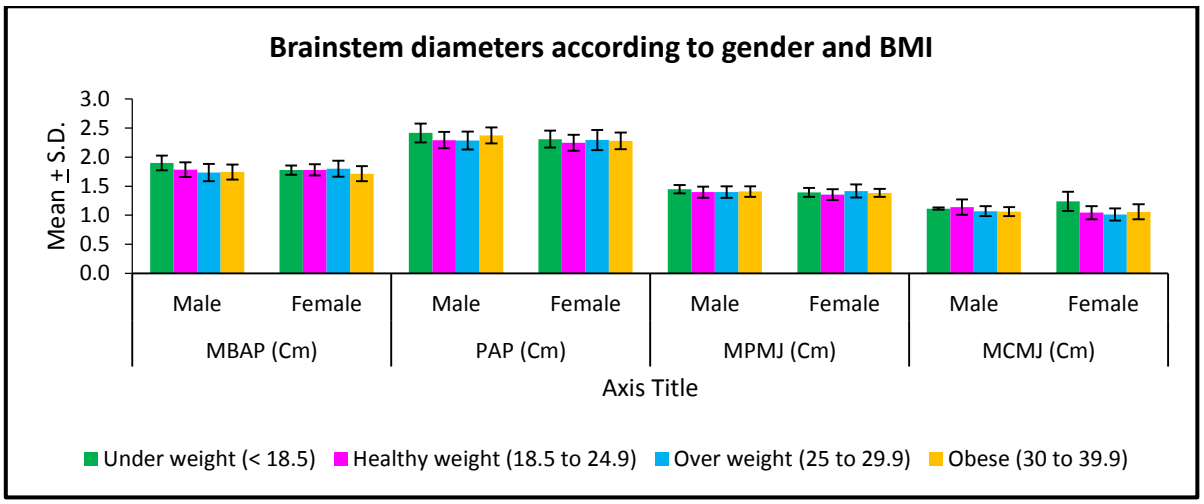
The one way ANOVA was used to compare brainstem diameters according to BMI. There was no difference ($p > 0.05$) in MBAP, PAP, MPMJ, and MCMJ according to BMI. [Table –5. 10]

Table 5.10: Comparison of brainstem diameters between males and females according to BMI

	BMI	Male		Female		"t"	p value
		Mean	S.D.	Mean	S.D.		
MBAP (Cm)	Under weight (< 18.4)	1.90	0.13	1.78	0.08	1.37	0.263
	Normal weight (18.4 to 25)	1.78	0.13	1.78	0.10	0.18	0.855
	Over weight (25.1 to 30)	1.73	0.15	1.80	0.14	-1.66	0.103
	Obese (3.1 to 40)	1.74	0.13	1.71	0.13	0.54	0.594
PAP (Cm)	Under weight (< 18.5)	2.42	0.16	2.31	0.15	0.78	0.491
	Healthy weight (18.5 to 24.9)	2.29	0.14	2.25	0.14	1.33	0.187
	Over weight (25 to 29.9)	2.29	0.15	2.29	0.17	-0.16	0.875
	Obese (30 to 39.9)	2.37	0.14	2.28	0.14	1.54	0.140
MPMJ (Cm)	Under weight (< 18.5)	1.45	0.07	1.39	0.08	0.84	0.461
	Healthy weight (18.5 to 24.9)	1.40	0.09	1.36	0.09	1.78	0.080
	Over weight (25 to 29.9)	1.40	0.10	1.42	0.11	-0.65	0.522
	Obese (30 to 39.9)	1.41	0.09	1.38	0.07	0.68	0.507
MCMJ (Cm)	Under weight (< 18.5)	1.12	0.02	1.24	0.17	-1.01	0.387
	Healthy weight (18.5 to 24.9)	1.14	0.13	1.04	0.11	3.35	0.001*
	Over weight (25 to 29.9)	1.07	0.09	1.02	0.11	2.06	0.044*
	Obese (30 to 39.9)	1.06	0.08	1.06	0.13	0.07	0.943

("t" = Independent sample "t" test; * Significant)

The Independent sample "t test was used to compare the brainstem diameters according to gender within BMI status. There was a difference ($p < 0.05$) MCMJ between males and females among the healthy weight cases as well as overweight cases. [Table – 5.11]



Graph 5.9. Represent the comparison of brainstem diameter between male and female according to BMI.

The graph 5.12 shows compare the brainstem diameters according to gender within BMI status. Between males and females among the healthy weight cases as well as overweight cases.

Table 5.11: Comparison of brainstem diameters according to BMI within gender

		Male				Female			
		Mean	S.D.	"F"	p value	Mean	S.D.	"F"	p value
MBAP (Cm)	Under weight (< 18.5)	1.90	0.13	1.44	0.238	1.78	0.08	1.68	0.178
	Healthy weight (18.6 to 30)	1.78	0.13			1.78	0.10		
	Over weight (25 to 29.9)	1.73	0.15			1.80	0.14		
	Obese (30 to 39.9)	1.74	0.13			1.71	0.13		
PAP (Cm)	Under weight (< 18.5)	2.42	0.16	1.25	0.301	2.31	0.15	0.60	0.614
	Healthy weight (18.5 to 24.9)	2.29	0.14			2.25	0.14		
	Over weight (25 to 29.9)	2.29	0.15			2.29	0.17		

	Obese (30 to 39.9)	2.37	0.14			2.28	0.14		
MPMJ (Cm)	Under weight (< 18.5)	1.45	0.07	0.22	0.883	1.39	0.08	2.17	0.098
	Healthy weight (18.5 to 24.9)	1.40	0.09			1.36	0.09		
	Over weight (25 to 29.9)	1.40	0.10			1.42	0.11		
	Obese (30 to 39.9)	1.41	0.09			1.38	0.07		
MCMJ (Cm)	Under weight (< 18.5)	1.12	0.02	2.50	0.067	1.24	0.17	3.45	0.02
	Healthy weight (18.5 to 24.9)	1.14	0.13			1.04	0.11		
	Over weight (25 to 29.9)	1.07	0.09			1.02	0.11		
	Obese (30 to 39.9)	1.06	0.08			1.06	0.13		

("t" = One way ANOVA)

The One way ANOVA was used to compare brainstem diameters according to BM within gender. There was no difference ($p > 0.05$) in MBAP, PAP, MPMJ and MCMJ according to BMI among males as well as females. [Table –5. 12]

Table 5.12: Relation between the various parameters of brainstem diameters

		MBAP (Cm)	PAP (Cm)	MPMJ (Cm)	MCMJ (Cm)
MBAP (Cm)	"r"	1	0.271	0.150	0.054
	p value	--	0.001*	0.061	0.498
PAP (Cm)	"r"		1	0.596	0.177
	p value		--	< 0.001*	0.027*
MPMJ (Cm)	"r"			1	0.215
	p value			--	0.007*
MCMJ (Cm)	"r"				1
	p value				--

("r" = Pearson correlation coefficient; * Significant)

The Pearson correlation coefficient ("r") was used to find the relation between the various parameters of brainstem diameters. The PAP was positively correlated ($p < 0.05$) with MBAP, MPMJ and MCMJ. Also, there was a positive correlation ($p < 0.05$) between MPMJ and MCMJ. [Table – 5.13]

Table 5.13: Relation between the various parameters of brainstem diameters according to gender

			MBAP (Cm)	PAP (Cm)	MPMJ (Cm)	MCMJ (Cm)
Male	MBAP (Cm)	"r"	1	0.437	0.183	0.146
		p value	--	< 0.001*	0.133	0.233
	PAP (Cm)	"r"		1	0.581	0.121
		p value		--	< 0.001*	0.323
	MPMJ (Cm)	"r"			1	0.188
		p value			--	0.122
	MCMJ (Cm)	"r"				1
		p value				--
Female	MBAP (Cm)	"r"	1	0.135	0.139	0.005
		p value	--	0.208	0.198	0.961
	PAP (Cm)	"r"		1	0.597	0.177
		p value		--	< 0.001*	0.098
	MPMJ (Cm)	"r"			1	0.199
		p value			--	0.063
	MCMJ (Cm)	"r"				1
		p value				--

("r" = Pearson correlation coefficient; * Significant)

Table 5.14: Relation between the various parameters of brainstem diameters according to age groups

			MBAP (Cm)	PAP (Cm)	MPMJ (Cm)	MCMJ (Cm)
20-30	MBAP (Cm)	"r"	1	0.516	0.388	0.049
		p value	--	< 0.001*	0.003*	0.722
	PAP (Cm)	"r"		1	0.692	0.261

		p value		--	< 0.001*	0.052
	MPMJ (Cm)	"r"			1	0.227
		p value			--	0.092
	MCMJ (Cm)	"r"				1
		p value				--
31-40	MBAP (Cm)	"r"	1	0.333	0.107	0.050
		p value	--	0.041*	0.523	0.764
	PAP (Cm)	"r"		1	0.491	0.168
		p value		--	0.002*	0.312
	MPMJ (Cm)	"r"			1	0.388
		p value			--	0.016*
	MCMJ (Cm)	"r"				1
		p value				--
41-50	MBAP (Cm)	"r"	1	-0.062	0.035	0.131
		p value	--	0.726	0.843	0.459
	PAP (Cm)	"r"		1	0.343	0.105
		p value		--	0.047*	0.554
	MPMJ (Cm)	"r"			1	0.090
		p value			--	0.613
	MCMJ (Cm)	"r"				1
		p value				--
51-60	MBAP (Cm)	"r"	1	0.517	0.170	0.136
		p value	--	0.004*	0.377	0.482
	PAP (Cm)	"r"		1	0.584	0.132
		p value		--	0.001*	0.495
	MPMJ (Cm)	"r"			1	0.286
		p value			--	0.133
	MCMJ (Cm)	"r"				1
		p value				--

("r" = Pearson correlation coefficient; * Significant)

Table 5.15: Relation between the various parameters of brainstem diameters according to BMI

			MBAP (Cm)	PAP (Cm)	MPMJ (Cm)	MCMJ (Cm)
Under weight (< 18.5)	MBAP (Cm)	"r"	1	0.959	0.535	-0.591
		p value	--	0.010*	0.352	0.294
	PAP (Cm)	"r"		1	0.409	-0.584
		p value		--	0.495	0.301
	MPMJ (Cm)	"r"			1	0.314
		p value			--	0.607
	MCMJ (Cm)	"r"				1
		p value				--
Healthy weight (18.5 to 24.9)	MBAP (Cm)	"r"	1	0.160	0.101	0.033
		p value	--	0.164	0.383	0.778
	PAP (Cm)	"r"		1	0.426	0.075
		p value		--	< 0.001*	0.517
	MPMJ (Cm)	"r"			1	0.176
		p value			--	0.126
	MCMJ (Cm)	"r"				1
		p value				--
Over weight (25 to 29.9)	MBAP (Cm)	"r"	1	0.316	0.257	-0.039
		p value	--	0.021*	0.063	0.782
	PAP (Cm)	"r"		1	0.787	0.304
		p value		--	< 0.001*	0.027*
	MPMJ (Cm)	"r"			1	0.350
		p value			--	0.010*
	MCMJ (Cm)	"r"				1
		p value				--
Obese (30 to 39.9)	MBAP (CM)	"r"	1	0.488	0.031	0.319
		p- value	--	0.021*	0.890	0.148
	PAP (CM)	"r"		1	0.627	0.485
		p- value		--	0.002*	0.022*
	MPMJ (CM)	"r"			1	0.206
		p- value			--	0.359

	MCMJ (CM)	"r"				1
		p -value				--

("r" = Pearson correlation coefficient; * Significant)

CHAPTER 6

DISCUSSSION

The brain stem is the relay center of the human brain which connects the cerebrum and spinal cord. It comprises the midbrain, pons, and medulla oblongata which control a number of important vital functions of the body, apart from housing various cranial nerve nuclei within.(23) This part connects the medulla spinalis to the top of the nervous system through a crossing of descending and ascending tracts .(6) The current study provides to obtain age, gender and BMIs matched normative references data for the various parts of the brainstem that can be extrapolated for physiologic/pathological change.In this study there were 157 subjects (69 male and 88 female), were included whose mean age is 37.81 years ,mean height is about 156.97cm which ranges (134.1 to 182.8) and mean weight is 60.89kg which ranges (40 to 80) and BMI of 24.78 kg/M^2 ranges (14.43 to 36.15).This study is performe on Siemens Magnetom Avanto 1.5 T MRI machine , subjects with MRI brain is include in this study.

AUTHOR	**MBAP(mean± SD)**	**PAP**	**MPMJ**	**MCMJ**
Amrutha et al.	1.67±0.17cm	2.16+0.18cm	1.39+0.16cm	1.08+0.13cm
S.O et al.	0.938±0.107cm	1.547±0.138cm	1.346±0.124cm	1.011±0.14cm
Singh et al.	1.70±0.12cm	2.2±0.13cm	1.3±0.088cm	_
Elameen Raae	1.807±0.159cm	2.318±0.134cm	0.807± 0.08cm	_
Our study	1.77±0.12cm	2.28±0.15cm	1.39±0.10cm	1.07±0.12cm

In this study, evaluated the linear midsagittal measurements of the parts of the brain stem in 157 subjects referred for MRI. The overall mean and standard deviation diameter of the brainstem among both males and females were found to be midbrain (MBAP)1.77±0.12cm(mean± SD),pons(PAP) 2.28±0.15cm (mean± SD) and for medulla oblongata at PM (MPMJ) 1.39±0.10cm(mean± SD) and CM(MCMJ) 1.07±0.12cm(mean± SD) when we compare the brainstem diameter according to gender there is difference in MCMJ. when we compare brainstem diameters according to gender within age groups we find that there is the difference in MBAP in both males and females, at PAP and MPMJ there is difference among females. when we compare brainstem diameters according to BMI there

is no difference in MBAP, PAP, MPMJ and MCMJ but according to gender within BMI there is difference in MCMJ between males and females among the healthy weight cases as well as overweight cases. All my given author does not included BMI on the given parameter but in my study I have included BMI.

Study done by **Amrutha et al**. [21], who recorded the overall mean and standard diameters of midbrain 1.67±0.17 cm (mean± SD), pons 2.16±0.18 cm (mean ±SD), medulla oblongata at PM 1.39±0.16 cm (mean± SD) and CM 1.08±0.13 cm (mean ±SD) junctions respectively. Which found that there is significant reduction in brainstem measurements at all levels with ($p<0.05$) with increasing age were recorded except medulla at pontomedullary junction it remain constant and also there was no significant difference found in brainstem measurements between male and females.Whereas in my study i found overall mean and standard deviation diameter of the brainstem midbrain(MBAP)1.77±0.12cm(mean± SD),pons(PAP) 2.28±0.15cm (mean± SD)and for medulla oblongata at PM (MPMJ)1.39±0.10cm(mean± SD) and CM(MCMJ) 1.07±0.12cm(mean± SD), there was the significant reduction in brainstem diamaters with increasing age which is similar to my study but in my study there was there is the significant difference in medulla pontomedullary junction which is not smilar to the author's study and also there is significant difference in MCMJ between both male and feamles.In my study I have included the parameter BMI and found that there is the significant difference ($p<0.05$) medulla at cervicomedullary junction(MCMJ)between both male and females among the healthy weight cases as well as overweight cases, which is not included in their study.

S.O et al.[6] who recorded the mean diameter of mid brain 0.938±0.107cm (mean ±SD), pons 1.547±0.138 cm(mean± SD), medulla oblongata at PM 1.346±0.124 cm (mean± SD) and CM at 1.011±0.14cm(mean±SD)respectively. There was significant difference in medulla oblongata medullospinal junction according to age groups of healthy females and males which is similar to my study which found that there is significant difference of ($p<0.05$). In females mesencephalon anteroposterior diameter value showed the reduction until the age of 61 year which is similar to my study at the age of 60 and after 60 this value increased which. I have not mentioned the age group after 60. In female highest value of pons anteroposterior

diameter was seen in The highest value was observed in individuals aged 31-40, while the lowest value was observed in individuals aged 61 and above. In males there was no statistically significant difference in all measurements but in my study there is the difference in MBAP among male according to age group. In my study I have included the parameter BMI and found that there is the significant difference($p<0.05$)medulla at cervico medullary junction (MCMJ) between both male and females among the healthy weight cases as well as overweight cases, which was not included in this study .

Singh et al.[31] states the over all mean diameter of midbrain 1.70±0.12cm (mean± SD), pons 2.2±0.13cm (mean± SD), medulla at PM 1.3±0.088cm(mean± SD), she did not included medulla Oblongata at cervicomedullary junction but in my study I have included medulla cervico medullary junction i.e MCMJ and found mean and standard deviation 1.07±0.12cm(mean± SD) The study found no significant correlation between the sagittal diameter of the midbrain, pons, and medulla and patient's gender. I found the significant difference ($p<0.05$) among midbrain, pons and medulla oblongata at pontomedullary junction with cervico medullary junction. Overall sagittal diameter of brainstem reached maximum in the age of 20 and stopped increasing which is similar to my study . Reduction of midbrain and medulla oblongata after the age of 50 which is similar to my study and significant decreased after the age of 70 i have not included the age of 70. There was no significant found in the parameter of pons after age which is simiar to my study. In my study I have included the parameter BMI and found the significant difference of ($p<0.05$)medulla at cervicomedullary junction(MCMJ) between both male and females among the healthy weight cases as well as over weight cases which is not included by the author in their study.

Elameen RA.[38] who recorded the over all mean diameter of brainstem among both male and females were found to be midbrain 1.807±0.159cm (mean± SD), pons 2.318±0.134cm (mean± SD), and medulla oblongata at PM are 0.807±0.08cm author have not included the medulla oblongata at CM but i have included in my study and found mean and standard deviation1.07±0.12cm(mean± SD).According to age mean and standard deviation is greater in male then female which is similar to my study that the male show higher mean as compare to female. Pons mean was greater than the mean of midbrain and medulla that is similar to my study and SD of midbrain is greater than the SD of pons and medulla. There is no relationship with the age as diameter decreases with increasing age but in my study there is the relationship between the various parameter of brainstem diameter decrease with

increasing age with ($p<0.05$) except the cervicomedullar junction there is no any difference according to age groups. In my study I have included the parameter BMI and found that is the significant difference in ($p<0.05$)medulla at cervicomedullary junction(MCMJ) between both males and females among the healthy weight cases as well as over weight cases which is not included in their study.

CHAPTER 7

CONCLUSION

Thus, basic linear brainstem measurements can be quickly and noninvasively obtain by using magnetic resonance imaging (MRI).

There is a statistically significant difference in the normal reference value for AP diameter between males and females.

Additionally, there is a difference in BMI between males and females across healthy weight ranges as well as overweight ranges. It is acceptable to use the study's normal range for evaluating any physiological changes in the brain stem.

There was a difference in all the AP diameters between males and females according to the age groups.

CHAPTER-8

LIMITATIONS OF THE STUDY

- Our study's limitation is the absence of volumetric investigation of brainstem structures , which could have improved the accuracy of the brainstem morphometry and BMI. We suggest conducting volumetric analysis study on this topic in the future.
- Subjects with the age of less than 18 year and more than 60 years may be included in this for the measurement variation.
- Larger sample size allow for the possibility of even the smallest measurement error , which could produce minute variations in the result.
- The male contenders were smaller than the female candidates, which might have affected the study's conclusions.
- In comparison with linear measurements, volumetric measurements might provide more information.

Scope for future study

- It can be used in neurological investigations using MRI brain scan to quantify the brainstem morphometric measurement.
- This study has the potential to be utilized to establish normative values based on age, gender and BMI's structural changes in the brainstem.

CHAPTER -9

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Subject: Grant of Ethical Clearance for **Dissertation Protocol** Topic **"Evaluation of the Brain Stem on the basis of Age, Gender, BMI by Using 1.5 Tesla MRI",** submitted by **POOJA SAINI,** student of M.Sc. Medical Imaging Technology, 2022 Batch.

*****

With reference to the request for grant of Ethical Clearance for the Dissertation Protocol entitled **"Evaluation of the Brain Stem on the basis of Age, Gender, BMI by Using 1.5 Tesla MRI"**, **POOJA SAINI** is informed that the **Dissertation Protocol** submitted by him/her was considered by the **Screening Committee** of the **Allied Health Sciences** in its meetings held on 07.02.2024 and 29.02.2024. The recommendations of the **Screening Committee** were considered in detail by the **Institutional Ethics Committee** in its meeting held on **15.05.2024** and the same was **approved** by the **Ethics Committee** of the **Santosh Deemed to be University, Ghaziabad, Delhi NCR**.

He /She is informed accordingly for further necessary action.

7/9/24

[Dr. EZHILRAJAN. K]
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M.Sc. Medical Imaging Technology.

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